

The Blast Furnace and Steel Plant

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Two Great Inventions

IN 1828, one hundred years ago, official recognition was given a method for heating the air that is used in the combustion of a fuel. This recognition was in the form of a patent issued to J. B. Neilson. Neilson's apparatus was crude and permitted an increase in the temperature of the air to only a few hundred degrees, but the principle was sound. Hence, although the apparatus mechanically was of little value, nevertheless, it was the first piece of mechanism that embodied a really practical method of heating air.

The contribution that Neilson made to the art of securing high temperatures has now been almost forgotten, but the principle to which he gave expression is still an essential requisite for every blast and open hearth furnace. Others, as is frequently the case, seized upon Neilson's idea and, by improving upon the mechanical details, or by an entirely different adaptation of the principle, have achieved success.

Thus, 28 years after Neilson's patent was issued, Frederick Siemens brought forth his system for raising the temperature of air. One employed a recuperator; the other regenerators.

To these two men belongs the credit for having made possible the production of steel and iron in large quantities, and at a comparatively low cost. The benefits the inventions conferred on mankind is beyond appraisal; but to what extent is unknown, except to those in the engineering profession. A place in the "hall of fame" is not always attained by a great service.

Dovel Type Blast Furnace Put on Test

Furnace at One of the Large Southern Iron and Steel Plants Is
Operated for Six Days on Burden of Crushed Ore—
Procedure Simulates Northern Practice

By JAMES P. DOVEL*

AFTER the installation of the new type Dovel furnace, one of the principal objects of design was to prevent the production of flue dust, and these losses were reduced from 400 to 500 lbs. per ton of iron to that of 24 to 50 lbs. There was then a great incentive to take advantage of the well known principle that the finer the ore the better the contact, and the consequent higher thermal efficiency. As conclusively proven by these tests (see screen test made of ore as ordinarily crushed and as recrushed), this recrushing increased the thermal efficiency about 16 per cent, and only increased the flue dust from 24.6 lbs. to 42.53 lbs. per ton of iron.

Most of the ore that is used in the Birmingham district is of the hard type and must be crushed. The question of what size it should be crushed to had never been definitely decided. There seemed to be a great diversity of opinion on the subject, notwithstanding the fact that these furnaces of the ordinary type were producing about the same amount of dust while running on hard ore crushed to 3 in. and under, as the northern furnaces running on very fine ore.

Another test was run for the purpose of determining whether this furnace would carry a very great percentage of fine concentrates without sintering. This was done by grinding ordinary hard ore in a rod mill to pass 20 mesh and charging every fourth charge of this material. No change was noted in the working of the furnace or in the dust produced, except that the furnace came very hot, due to the increase in thermal efficiency which was overlooked at the time of starting the test and was taken care of by lowering the temperature of the hot blast.

Furnace—Improved Dovel type blast furnace, double skip filled McKee top, of following dimensions:

Height	85 ft.
Hearth diameter	14 ft. 9 in.
Bosh diameter	21 ft. 0 in.
Bosh angle	77 deg. 0 min.
Stock line	17 ft.
Large bell	9 ft. 7½ in.
Batter of inwall	½ in. per ft.
Ten standard tuyeres	6 x 10½ in.
Total cubical capacity	20,531 cu. ft.

The stack is equipped with nine rows of Dovel inwall cooling blocks and has a metal top.

Stock Trestle—Single line of bins spanned by double track.

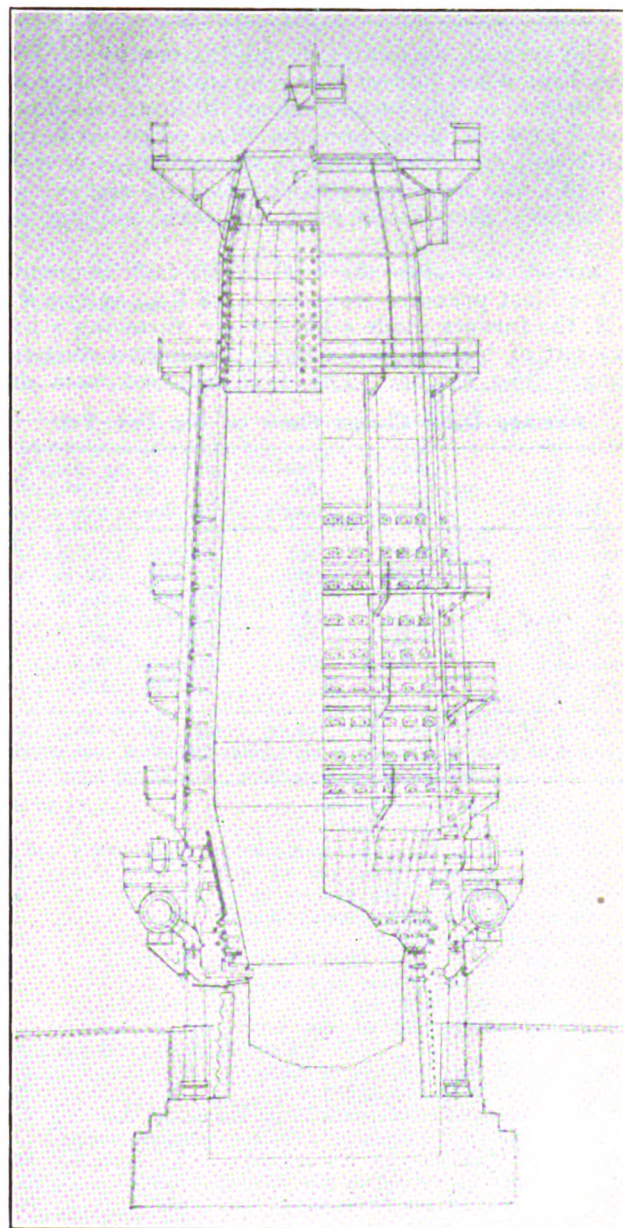
Stock House—Single line larry track for all raw materials. Ores and stone are weighed in larry car; coke is measured, being drawn from bin located directly over skip pit direct into skip car. Skip car capacity approximately 3,000 lbs. coke.

*Vice president, Sloss-Sheffield Steel & Iron Company.

Stoves—Six 4-pass Whitwell stoves. Total heating surface 130,000 sq. ft.

Gas Cleaners—One vertical dust catcher, and a Dovel dry dust catcher and cleaner. The Dovel cleaner consists of a large main containing a series of baffles, under and over which the gas passes. As the dust is deposited it is washed to a sump, where it settles out of the water.

Heat Recuperator—This is a Dovel heat recuperator for hot blast. It consists of a series of pipes connected together in one line, through which the cold blast is blown before reaching stoves. Waste gases from



Outline of typical Dovel blast furnace.

stoves are passed over these pipes, which serve to heat cold blast to about 450 deg. F.

Blowing Equipment — Four Allis-Chalmers, long cross-head type reciprocating blowing engines, 44 x 84 x 60 in. Theoretical capacity of blowing tubs, 384 cu. ft. per revolution.

Steam Plant—Two Casey & Hedges boilers, capacity 600 hp. each. Six Rust boilers, capacity 400 hp. each.

Six Day Test Run

At 6:00 P. M. September 26, 1928, a six day test was started, using hard ore crushed to 1 in. through a crusher at the Sloss-Sheffield slag plant.

Burden and mixtures were as follows:

Ratio ore to coke	2.40:1.00
Mixture	Per cent
Hard ore	76
Brown ore	24
	100
Dolomite	600 lbs. per charge
Coke	6300 lbs. per charge

The furnace was carrying approximately 1275 degrees heat when put on above mixture, but after this burden was on the furnace about 10 hours it showed from 3 to 4 lbs. more pressure than when on burden with larger ore. When furnace showed signs of working tight, the heat was reduced to 1165 degrees and the furnace then worked very smooth, moving regularly.

Immediately after the 8:00 P. M. cast, September 27, the blast pressure went up to 28 lbs., and at 8:20 P. M. the furnace made a hard move, throwing a little coke out of bleeder and a large amount of dust into primary dust catcher. The dust removed from dust

Average Daily Charge Sheet on Six Day Test

Materials	Lbs. per charge	Total No. charges	Total lbs.	Total tons	Per- cent
Sloss hard	11,400	985	11,229,000	5,012.9	73.04
Brown ore	3,800	985	3,743,000	1,849.5	26.96
Total ore	15,200	985	14,972,000	6,862.4	.....
Coke { Wet	6,416	985	6,320,000	3,160	.....
{ Dry	6,253.6	985	6,159,808	3,079.9	.....
Limestone	595.8	985	586,880	262	.....
Scrap iron .....	.....	...	277,760	124	.....

(Scrap iron is other than runner scrap, but is that which is caught at slag screen and is an accumulation of one month).

Ratio of carbon to gross burden	1 to 3.17
Per cent of gross burden yield	37.4
Average cu. ft. wind blown per min. (363 cu. ft. per rev.)	47,444
Average blast pressure (lbs. per sq. in.)	20.6
Average top pressure (ozs. per sq. in.)	12.0
Average top heat (approximately), deg. F.	600
Average stove heat, deg. F.	1,199
Average warm blast (cold blast) heat, deg. F.	466
Average chimney valve heat at stoves, deg. F.	801
Average waste gas heat, deg. F.	499
Average lbs. coke per ton of iron, lbs.	
..... (Wet 2,220.6); (Dry)	2,164.3
Average pounds ore per ton of iron	5,260.7
Average pounds stone per ton iron	206.2
Theoretical metallic yield (94% Fe in iron), per cent..	43.15
Actual metallic yield (based on 2,794 tons account scrap iron), per cent.....	40.71
Pounds of flue dust caught in dust catcher (6 days)....	84,440
Pounds of flue dust caught in sump, (6 days), (dry) ..	36,608
Total flue dust caught, lbs.	121,048
Total pounds flue dust per ton of iron	42.53

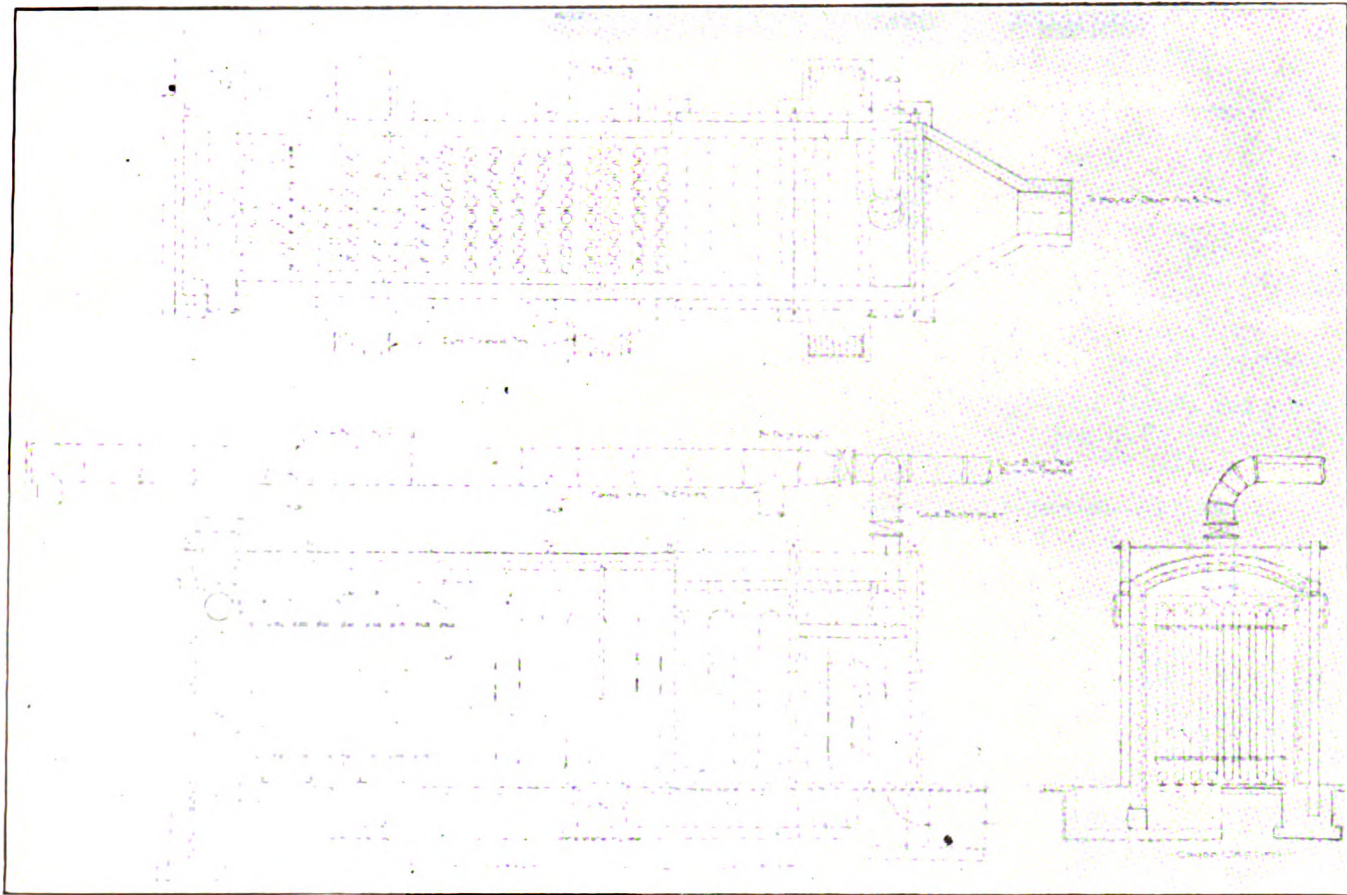
catcher after this hard move was as much as was caught the following four days.

After the furnace made this hard move, it seemed to work very smoothly during the remainder of the test. The pressure dropped back to 18 or 20 lbs., remaining so except, of course, for about 30 minutes following each cast, when it would be up about 2 or 3 lbs.

The dust caught in the primary dust catcher for the six days weighed 84,440 lbs. The dust caught by

Iron Production, by Grades, for Six Days of Test

Casts	Tons	Grade	Sil.	Sul.	Phos.	Mn.
1	70	2F	2.18	.036	.77	.52
	27	2S	2.53	.034	.77	.52
2	95	2F	1.94	.038	.77	.46
			1.90	.034	.77	.46
3	51	1S	3.10	.031	.77	.56
	20	2S	2.60	.028	.77	.56
4	94	2F	2.00	.034	.77	.48
			2.00	.032	.77	.48
5	98	2S	2.55	.027	.77	.54
			2.57	.026	.77	.54
6	108	2F	1.95	.031	.79	.50
			1.95	.027	.79	.50
7	95	3F	1.70	.035	.79	.57
			1.67	.032	.79	.57
8	80	2F	1.85	.031	.79	.60
			1.85	.031	.79	.60
9	97	3F	1.60	.030	.79	.57
			1.55	.026	.79	.57
10	100	3F	1.60	.030	.79	.57
			1.56	.026	.79	.57
11	103	3F	1.55	.030	.78	.53
			1.55	.028	.78	.53
12	94	3F	1.30	.036	.78	.56
			1.27	.037	.78	.56
13	37	3F	1.62	.035	.78	.57
	50	2F	1.88	.035	.78	.57
14	90	2F	2.20	.032	.78	.57
			1.88	.035	.78	.57
15	86	2F	2.21	.033	.78	.54
			2.26	.034	.78	.54
16	105	2F	2.21	.032	.73	.62
			2.00	.035	.73	.62
17	44	2S	2.30	.038	.73	.59
	45	2F	2.14	.037	.73	.59
18	101	2F	2.25	.037	.73	.63
			2.20	.036	.73	.63
19	95	2F	2.00	.041	.73	.61
			1.85	.038	.73	.61
20	90	2F	2.00	.037	.73	.60
			1.91	.034	.73	.60
21	50	2S	2.29	.040	.80	.46
	52	2F	2.11	.036	.80	.46
22	57	2S	2.49	.034	.80	.44
	35	2F	2.16	.033	.80	.44
23	96	2S	2.40	.032	.80	.45
			2.48	.032	.80	.45
24	97	2F	2.15	.034	.80	.42
			2.15	.032	.80	.42
25	98	2F	2.21	.032	.80	.55
			2.10	.030	.80	.55
26	91	2S	2.83	.031	.77	.52
			2.83	.029	.77	.52
27	90	2F	1.95	.034	.77	.49
			1.91	.031	.77	.49
28	106	2S	2.50	.030	.77	.52
			2.40	.033	.77	.52
29	92	2S	2.70	.025	.77	.48
			2.61	.024	.77	.48
30	96	2F	2.10	.034	.77	.52
			2.06	.030	.77	.52
30	2835	11 of "Jumper Iron"				
Total—	2846					
Average			2.04	.032	.77	.53
Average daily tonnage for six days						474.3



Sectional views of recuperator which with the hot blast stove heats the air.

the Dovel gas cleaner and deposited in the sump was taken out immediately following the test, loaded in a car and allowed to drain over night. Then a moisture sample was taken and the dust weighed, which showed 51,200 lbs. dust wet basis. The moisture test showed 28.5 per cent. Weight of dust from sump on dry basis 36,608 lbs. This makes a total of 121,048 lbs. of dry dust produced from the primary dust catcher and Dovel gas cleaner during the six day test, or 42.81 lbs. per ton of iron produced. Dust in the gas going

Flue Dust Test Made of Gas in Flue from Stoves, Aug. 2, 1928

	No. 1	No. 2
Temperature gas at meter, deg.	100	93
Temperature gas in flue, deg.	670	665
Cubic feet gas metered	29.829	16.877
Cubic feet gas standard conditions	27.698	15.869
Grams dust	.2256	.1034
Grains dust	3.48145	1.59567
Grains dust per cu. ft. test conditions....	.11	.0945
Grains dust per cu. ft. standard conditions	.12	.1000

SUMMARY OF TESTS—DOVEL GAS CLEANER

Trial number	1	2	3	4	5	6	7
Filter number	1	2	3	4	5	6	7
Date	4/28/28	4/28/28	4/28/28	4/28/28	4/30/28	4/30/28	4/30/28
Average gas pressure, inlet side of cleaner (3 points) ins. Hg.	1.1	.....	.....	.....	1.15	.....	.....
Average gas pressure, outlet side of cleaner (3 points) ins. Hg.	1.	.....	.....	.....	1.05	.....	.....
Aver. gas pressure, drop through of cleaner (3 points) ins. Hg.	.1	.....	.....	.....	.1	.....	.....
Average gas temperature, inlet side of cleaner (3 points) deg. F.	475	.....	.....	.....	505	.....	.....
Aver. gas temperature, outlet side of cleaner (3 points) deg. F.	430	.....	.....	.....	460	.....	.....
Aver. gas temp., drop through of cleaner (3 points) deg. F.	45	.....	.....	.....	45	.....	.....
Gallons water per minute through cleaner	310	.....	.....	.....	310	.....	.....
Temperature water inlet to cleaner, deg. F.	118	.....	.....	.....	119	.....	.....
Temperature water outlet from cleaner, deg. F.	128	.....	.....	.....	129	.....	.....
Temperature rise of water in cleaner, deg. F.	10	.....	.....	.....	10	.....	.....
Btu. absorbed by water per min.	25,730	.....	.....	.....	25,730	.....	.....
Per cent of loss absorbed by water	71.2	.....	.....	.....	68.5	.....	.....
Duration of test, minutes	60	50	55	40	55	60	60
Gas Meter—Cu ft. gas: (Test conditions)	17.691	18.56	21.188	15.925	20.328	23.977	16.232
(Standard conditions)	15.2	15.367	17.4	13.377	18.905	19.35	13.635
Dust in Filter—Grams	.3854	.4030	.5752	.4480	.4906	.6126	.4343
Grains	5.946	6.1191	8.876	6.913	7.571	9.454	6.7021
Gas leaving cleaner } Grains per cu. ft. gas (test conditions)...	.3305	.329	.418	.434	.372	.352	.419
} Grains per cu. ft. gas (standard conditions)	.3912	.398	.510	.510	.400	.48	.491
Meter Data—Dry bulb temperature, deg. F.	95	100	102	101	74	110	107
Pressure of gas at meter (ins. HG.)	.15	.15	.15	.15	.15	.15	.15

TOTAL IRON MADE, BY GRADES, AT CITY FURNACE NO. 2, FIRST EIGHT MONTHS, 1928

Months	Total made each month	4.25 4.75	3.75 4.25	3.25 3.75	2.75 3.25	2.25 2.75	1.75 2.25	1.25 1.75	1.00 1.50	Mott.
January	13,230	....	....	281	1370	4838	6001	740	....	...
February	12,600	....	....	82	681	4553	5904	1380	....	...
March	13,640	....	....	362	1071	5473	5301	1244	189	...
April	13,060	....	....	751	1145	3947	5592	1390	235	...
May	13,720	....	31	301	428	4611	4561	3443	309	36
June	13,360	....	....	159	91	4466	5545	2976	123	...
July	13,730	70	174	956	1241	4166	5592	1531	....	...
August	13,560	30	....	791	1750	5707	4521	761	....	...
Total	106,900	100	205	3683	7777	37761	43017	13465	856	36
Per cent .....	.....	.09	.19	3.45	7.28	35.32	40.24	12.60	.80	.03

from the gas cleaner to boilers and stoves is not included, but the clean gas from the gas cleaner contains .3 of a grain per cu. ft.

Screen Test—Recrushed Sloss Hard Ore
From Crusher

Retained on—	Per cent
3 in. ....	....
2½ in.	.4
2 in.	1.9
1½ in.	8.8
1 in.	28.3
½ in.	22.6
¼ in.	12.0
4 mesh	1.9
8 mesh	6.6
10 mesh	1.5
20 mesh	4.5
40 mesh	4.7
60 mesh	2.6
80 mesh	.3
100 mesh	.8
200 mesh	3.1
Through 200 mesh	None

From Mines

Retained on—	Per cent
3 in.	15.8
2½ in.	15.8
2 in.	21.3
1½ in.	10.7
1 in.	9.8
½ in.	8.07
¼ in.	5.2
4 mesh	.8
8 mesh	3.2
10 mesh	.8
20 mesh	2.3
40 mesh	2.4
60 mesh	1.3
80 mesh	.1
100 mesh	.3
200 mesh	1.5
Through 200 mesh	None

Operating Data No. 2 City Furnace
January through August, 1928

The charge	Totals	Lbs. per charge	Average per day	Average per cent
Number	43,895	....	179.9	....
Coke (wet) .....	....	6,261	....	....
Coke (dry) .....	....	6,061	....	....
Tons coke	137,427	....	563.2	....
Hard ore tons	193,924	9,896	794.7	76.14
Brown ore tons	60,541	3,089	248.1	23.76
Manganese ore tons	235	12	.96	.1
Total ore tons	254,700	12,997	1043.8	100.00
Limestone tons	11,845	604	48.5	....

Operating data	Average 8 months
Ratio carbon to gross burden	1 to 2.70
Per cent gross burden yield	37.8
Average wind blown per min., cu. ft.	45,642
Average stove heat, deg. F.	1,303
Pounds coke per ton of iron (Wet, 2,571) ; (Dry, 2,486)	5,337
Pounds ore per ton of iron	58.4
Cubic feet wind blown per pound of coke charged..	58.4
Average slag analysis—	
Silica	38.18
Alumina	15.34
Lime	46.09
Sulphur	1.17
Average ore analysis—	
Silica	11.35
Alumina	3.39
Met. iron	39.11
Insol.	13.64
Lime	24.20
Manganese	.39
Phosphorus	.31
Fe ₂ O ₃	54.75
Average coke analysis—	
Volatile Matter	1.66
Fixed carbon	84.89
Ash	13.79
Sulphur	.70
Moisture	3.21
Average daily output, tons	438.1

Ore Analysis

	Sloss hard (Sept.) per cent	Brown ore (6 days) per cent
Silica	11.24	9.69
Alumina	3.26	2.40
Met. iron	36.57	51.43
Insol.	13.27	12.10
Lime (CaCO ₃)	29.76	....
Phosphorus	.31	.42
Manganese	.18	1.06

Limestone

	Per cent
Silica	.80
Alumina	.60
CaCO ₃	55.80
MgCO ₃	42.80

Coke

	Per cent
Volatile matter	1.50
Fixed carbon	85.47
Ash	13.03
Sulphur	.70
Moisture	2.00

(Continued on page 1570)

Chain Transfer Tables for Blooms

Routing from the Shear to Four Distinct Operations Is Accomplished, thus Allowing the Special Treatments Necessary in the Production of Alloy Steel Blooms in Quantity

THE quantity production of alloy steels covering a wide variation in analyses involves several difficult problems in the routing and treatment of material. For, having once reached the bloom stage, different steels require different treatments before further processing, which gives rise to problems concerning the most economical method of routing large quantities of material coming from a single source, to any one of several destinations. For example, in the new plant of The Timken Steel & Tube Company, blooms coming from the shear must be routed, according to analysis, either direct to the next rolling operation in the 28-in. mill; to continuous reheating furnaces, to thermal conditioning pits, or to a point where they can be pickled and ground, or chipped, before reheating and rolling. In other words, large quantities of material coming from one operation must be diverted to any one of four others, with as little possible obstruction to the production stream, either preceding, or subsequently.

In this particular case the solution has been arrived at by means of a chain transfer table which incorporates several novel features in design and construction. The table, which has an overall length of 81 ft., and a width sufficient to accommodate either two rows of 9-ft. blooms, or a single row of 18-ft. blooms, was built with special regard to the service desired. It is located at right angles to the shear runout table, so that it can handle all blooms coming from the shear, regardless of their ultimate destination.

Design of Transfer Table

The construction of the table proper is quite simple. It consists of a series of heavy rails, acting as skids, supported by a structural steel frame work consisting of heavy transverse channel members about 6 ft. apart, which are in turn supported at the ends by structural uprights, which, for greater rigidity are braced by cross members extending from the top of one column to the base of the adjacent ones on each side. Further rigidity is given to the individual supports by gusset plates at the joining angle of the transverse and upright members. The table has a total rise of 6 ft. from the charging to the discharge

and, above ground level, with a level point about 15 ft. from the end nearest the hot shear, where the runout table leading to the 28-in. mill is located. This arrangement gives the operator a clear view of the blooms on the table during the whole course of their travel over it, from his pulpit over the charging end.

Bloom travel is accomplished by four endless chains, provided with carrying dogs, which extend 4 in. above the surface of the skid rails. The chains are driven from four sprockets mounted on a common shaft at the delivery end of the table, and run over four spring sheave take-up sprockets at the shear table end. The drive consists of a 90-hp. 220-volt compound wound, mill type motor, which drives the sprocket shaft through a reduction unit which gives a chain speed of 150 ft. per min. The motor is provided with a solenoid brake to insure quick stopping when blooms are to be spotted on the runout tables that deliver them to various destinations.

The four sprockets at the drive end are mounted on a common shaft, which is coupled directly to the main gear shaft of the reduction unit. The sprocket shaft in reality consists of two sections of about equal length, coupled together. Thus either section may be removed, if desired, without disturbing the rest of the assembly. The shaft is supported by five pillow blocks, so located as to give it the greatest possible rigidity, that are equipped with Timken bearings. The mountings are quite simple, the two bearing cones being pressed on the shaft, and the cups located by a shoulder on the inside of the plate which forms the outer closure, adjustment being obtained by means of shims. The pinion and gear shafts of the reduction unit are also mounted in Timken bearings.

The mounting of the take-up sprocket bearings is quite different. The sprocket bearings are located inside the sprocket hub proper, the cups being pressed against shoulders inside the hub, and the cones given a light fit on the shaft. The cones are located by a sleeve which fits around the shaft inside the square sliding block, and are locked in place by nuts on the end of the shaft. The outer closure is formed by a

(Continued on page 1570)



(Left)—General view of the transfer table from the operator's control station. (Center)—The control station, showing the control panels and master switches for the chain transfer and runout tables. (Right)—The table drive, showing the type of roller bearing pillow blocks used to support the shaft.

Value of Insulation in the Steel Plant

A Practical Review of the Various Applications of Heat Insulation to Furnaces and Auxiliary Equipment—Cost and Savings Compared Show Substantial Returns on the Investment

By L. B. McMILLAN* and J. D. Van VALKENBURGH†

THE use of heat insulation as a measure of economy and as a means to improve production has assumed new importance in the steel industry during the last 10 years. With advancing operating costs, keener competition and a falling off of markets, the plant engineer must concentrate his attention on the employment of the most profitable features of improved furnace construction.

A handsome return on investment available to an industry primarily concerned with the generation and application of heat may be secured by spending for suitable insulation that which otherwise will shortly be spent in wasted fuel and impaired production.

The intention of this article is to briefly discuss utility of insulation in the blast furnace and steel plant, show what it accomplishes and illustrate its usefulness on certain specific furnaces. Generalities do not satisfy the needs of the designer, but an analysis of the uses of particular materials and approved details of application requires special treatment. For present purposes it is sufficient to say that much progress has recently been made in the development of thermally efficient insulating materials, capable of withstanding high temperatures, and with physical properties suited to uses where insulation of any sort has formerly proven inadaptable.

Heat Wasted by Radiation

While divers savings of various magnitudes in different furnaces result from the proper use of suitable insulation, the one which ordinarily lends itself most readily to arithmetical expression is direct reduction in heat loss per square foot of furnace surface.

Some idea of the extent of these losses may be gained by referring to the chart in Fig. 1. If observed temperature difference between outside surface of the furnace wall and room air is located on the horizontal scale, the heat loss per square foot per hour may be read on vertical scale for various air velocities over the surface.

If outside surface temperature cannot be estimated, but brick temperature on the furnace side of a certain thickness of firebrick is shown, then bare loss for zero air velocity over the surface, and 75 deg. F. room temperature, may be discovered by reference to the chart in Fig. 2, prepared for conservatively low values of firebrick conductivity and published herewith for the first time in the form shown. Selecting a furnace temperature for a certain brick thickness in the lower left hand portion of the chart and projecting horizontally in a right hand direction to the curve marked "zero inches" of insulation, then projecting vertically upward to the intersection of the transposition curve in the upper left hand corner of the chart, the Btu.

loss may be determined directly by projecting horizontally to the Btu. scale at the left.

If instead of using the "zero inches" of insulation curve, an actual value be assumed for insulation thickness, corresponding heat losses for given conditions of operation may be read from the chart by proceeding as outlined above.

Factors Governing Insulation Thickness

If it be assumed that the proper insulating material has been selected for a specific application, and a satisfactory manner of introducing it into the construction of insulation should be used resolves itself into a determination of economical thickness—a balance between cost per year of insulation, and cost of

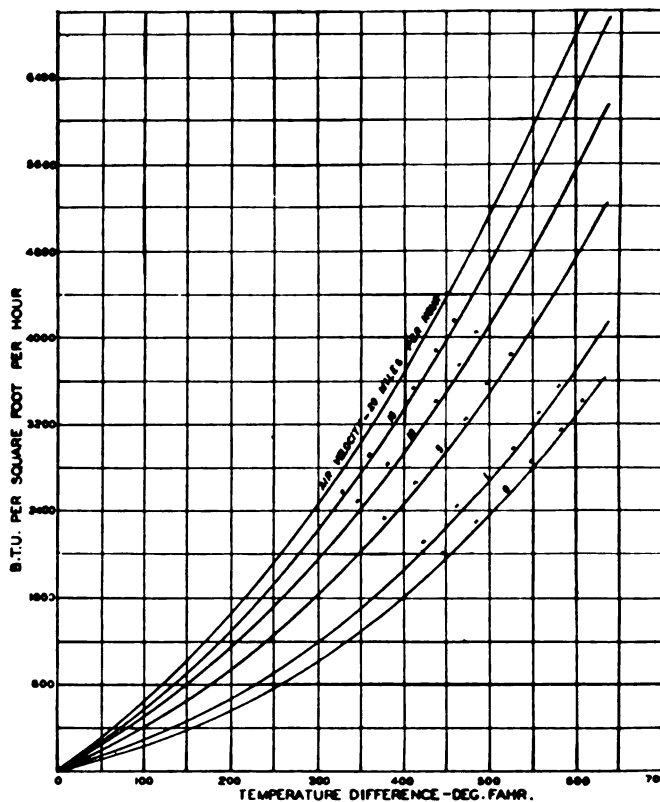


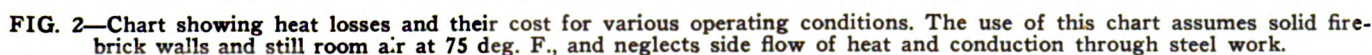
FIG. 1—Chart showing heat losses from hot surfaces.

heat loss per year plus other evaluated benefits. The other conditions which must be met take cognizance of the temperature limits of the refractories used in the construction, and provide that the insulation itself will be subject to a range of operation wherein it will maintain suitable physical characteristics.

Methods of computation are available for appraising the importance of these interrelated factors, and anyone familiar with performing the calculations soon arrives at the logical solution. The chart in Fig. 2 permits one to determine the approximate economical thickness by the use of graphical methods, which will

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The chart may thus be used for two different thicknesses of insulation and the same furnace conditions to determine the amount of the saving per year which results from the use of the thicker insulation; or, similarly, a contrast may be made between the cost of heat lost with no insulation and with a certain thickness of blocks.

If no insulation is used on a furnace, the user must pay the entire yearly cost of bare furnace heat loss. If a certain thickness of suitable insulating blocks are supplied with the construction, the user must pay the

yearly cost of a reduced heat loss and also the yearly cost of insulation material and erection. Both of these costs are charges against furnace operation. The thickness of insulation at which the sum of these costs is

The blast furnace itself has been usefully served by installing rings of an exceptionally durable insulating block at each second lap of the steel shell surrounding the inwalls, as shown in Fig. 3. In order to stand up under the stress transmitted to it by expanding brick and still maintain the necessary resilience, the insulation used for this purpose must be of a particular character, specially manufactured for such usage. The rings themselves keep the filling material, sometimes used between inwalls and shell, from settling over a greater height than the distance from top to bottom of two plate courses. Furthermore, high temperature furnace insulation is now being manufactured which may economically be used to replace the loam or slag sometimes used over the upper inwall without danger to refractories.

One function of insulation in connection with the blast furnace and its accessory equipment may be illustrated by hydraulic analogy.

Suppose a mill dam 15 ft. high has 1 in. of water flowing through the flume to the waterwheel. Then

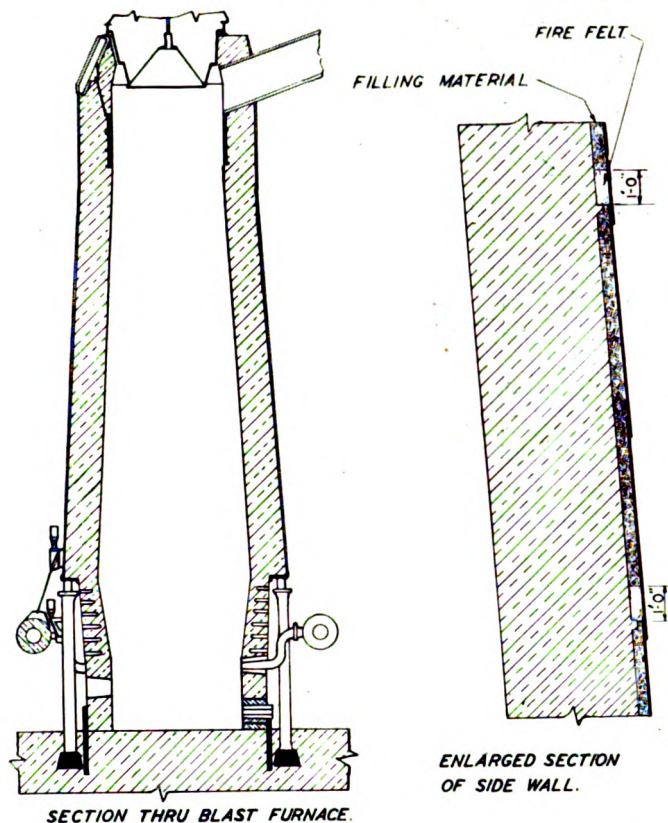


FIG. 3—Insulation in the blast furnace. Sketch showing rings of insulation for supporting filling material between blast furnace shell and upper inwalls.

a minimum therefore constitutes the economical thickness. This condition exists when the final increment of insulation just pays fixed charges against its cost.

Supposing that the insulating blocks, in place, cost an average of \$0.20 per square foot per inch of thickness, and that fixed charges covering amortization, interest, insurance, taxes, etc., amount to 25 per cent of initial cost, then the cost per year of insulation averages \$0.05 per square foot per inch of thickness. In this case the economical thickness of insulation would be approximately that with which the final inch saves \$0.05 worth of heat per year. By following through the chart in Fig. 2 for successive inches of insulation thickness, the point may be reached at which this condition exists, and the approximate economical thickness thus determined by trial. The size of the chart may render interpolation difficult, but the effect as noted is easy to discern.

Insulation on the Blast Furnace and Accessory Equipment

It is often true that other considerations enter into the analysis, and not infrequently the determining factor in the specification of insulation is not heat loss at all, but rather equalization of the load on refractories, reduction of air leakage through the walls or other matters of even greater import than radiated heat. The importance of these factors will be somewhat clearer after a general discussion on the effectiveness of insulation as applied to particular furnaces.

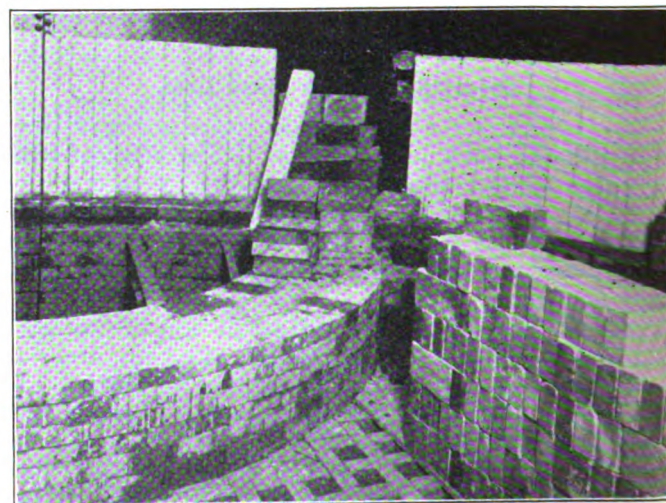
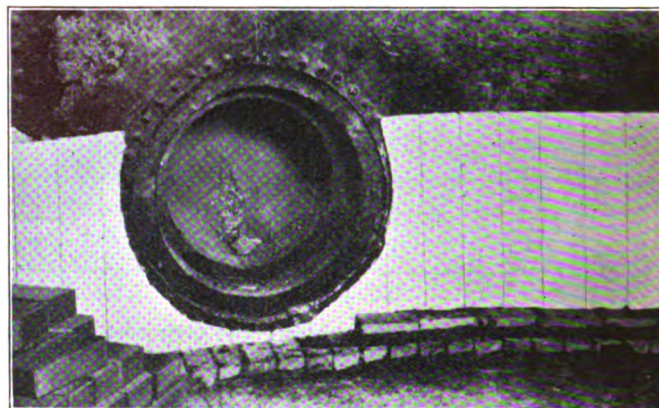


FIG. 4 (upper)—Erecting the lining in hot blast stove. First row of insulating blocks is in place against the shell and brickwork is just started. Base insulation as shown at the bottom has been allowed to harden and set before any brick is laid. FIG. 5 (lower)—Hot blast stove insulation and brickwork. Progress picture showing the construction of side combustion stove at the plant of the Shenango Furnace Company, Sharpsville, Pa.

suppose that due to a change in level, 11 in. of water flow through the flume. This flow is independent of the fact that the dam is 15 ft. high, and the percentage difference in total depth of water on the upstream side

of the dam is only $5\frac{1}{2}$ per cent, but the effective amount of water available to do useful work below the dam in the second case is increased 1,000 per cent over the first case.

Similarly, if a blast furnace is operated with cold blast, the heat of the coke is just about enough to smelt the iron. Any additional heat that can be supplied may constitute a very small percentage of the total, but may represent a very large percentage of the heat available at a high enough temperature to carry on the necessary chemical reactions. This permits leeway, generally improves furnace operation, and makes for better control.

If this additional heat is so conducive to improved operation, how can it be supplied? The answer, of course, lies in the universal practice of heating the blast; the proper insulation of hot blast stoves, mains and bustle pipes; the dehumidifying of blast air, etc.

The importance of heat conservation in hot blast stoves, mains and bustle pipes has long been recognized. If the expense of heating the blast is so well justified, it is certainly worth while to take some precautions to keep the air at high temperature till it reaches the tuyeres.

In the early days of Thomas recuperative stoves, it was the custom to test the hot blast with strips of lead and strips of zinc. If the lead melted, the blast

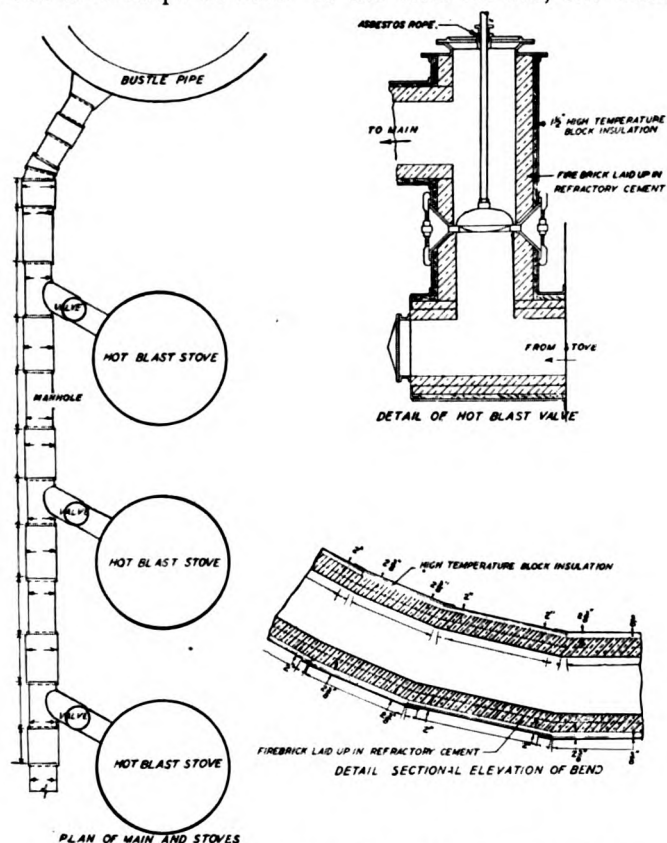


FIG. 6—Hot blast main insulation. Drawing illustrating application of insulated lining.

was thought to be hot enough to do its work, but if the zinc melted, it was too hot and would "burn the iron." Such ideas seem ludicrous in the light of the present day knowledge that every extra available Btu. in the blast ordinarily means improvement in furnace operation, and combustion air of a temperature of at least 1,000 deg. F. is listed among first requisites to satisfactory performance.

Where methods of cleaning the blast furnace gas do not necessitate the wasting of sensible heat, it is also practical to insulate the uptakes, downcomers, dust catchers, dry filters, etc. Of course, if wet scrubbers or gas washers are used, the heat in the gas is wasted to water and little benefit results from heat conserved throughout the remainder of the gas line. However, except where gas engines are to be operated with blast gas, exacting dust requirements need not

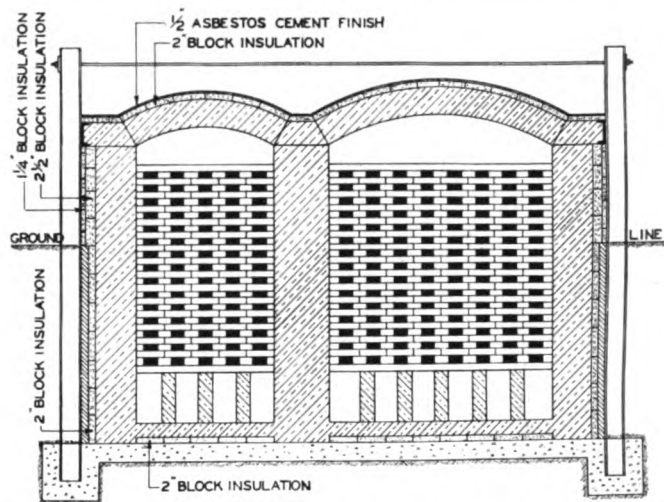


FIG. 7—Insulation of open-hearth regenerators. Section of typical insulated checker chambers made up in accordance with recommendations for new installations.

be met, and the use of dry cleaning equipment, insulated to save sensible gas heat, seems to be the logical order.

Standard insulation specifications have been in use for years in connection with lining hot blast stoves. Base insulation for stoves is rather recent in comparison, but at present is considered as important as waterproofing. For such applications as these, the problem of heat conservation is no longer a matter of trial and error. Materials and methods have been developed to a stage where there is no question as to what constitutes best engineering practice.

Aside from the points usually mentioned with respect to insulated blast stoves, there is another which is by no means of small importance, and that regards the decreased range of hot blast temperature variation. It is common knowledge that better blast furnace control results from more uniform temperature on the blast, and best practice directs that the maximum drop in temperature should not exceed 100 deg. F. per hour. By curtailing the extremes of temperature variation within the stove during the entire cycle of operation, a properly insulated lining has an important beneficial effect on limiting the range of temperatures.

During the last decade improvements in design, such as mentioned above, have been so marked as to increase hot blast stove furnace efficiency from about 50 per cent to about 70 per cent. Such savings as these count for a great deal more in overall efficiency of the plant than their proportional saving of heat units, though this in itself is enormous.

In the matter of delivering high temperature blast at the tuyeres, the insulation of mains and bustle pipes is equally vital. There can be no question of the desirability of this practice if reference is made to the

numerous successful installations of high temperature block insulation between the steel shell and the firebrick lining of mains which have been in extended use.

A lining failure in hot blast main or bustle pipe is an affair of no mean consequence. The cost of labor and materials incidental to repair is a factor without importance compared to interruption of production

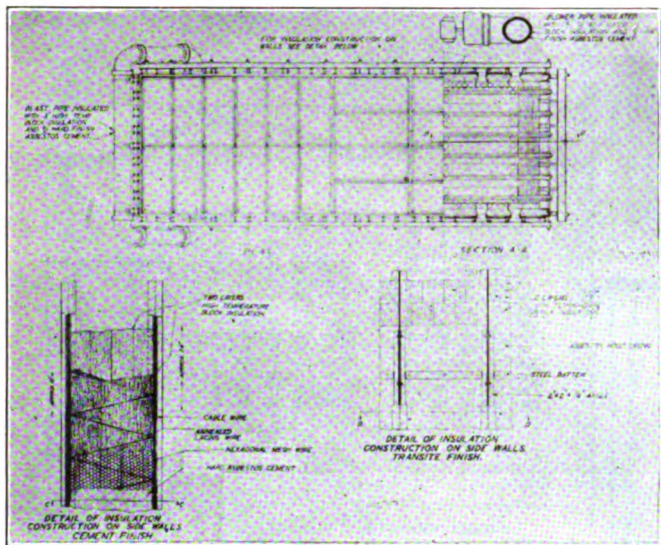


FIG. 8—Billet heating furnace insulation. Drawing illustrative of a standard insulation specification as applied to one type of billet heating furnace.

and furnace difficulties. The superintendent is well justified, therefore, who eyes with suspicion the general use of any but well tried methods and materials. Linings are subject to harsh abrasive action, enormous stresses from firebrick expansion, and general severe operating conditions, all of which demand the use of a mechanically strong block with insulating quality of the first order, capable of enduring high temperatures without harmful effect upon its physical properties.

These specifications may seem hard to meet, but developments in this field have been rapid in the last few years, and it is now a matter of current report that the insulation of hot blast mains and bustle pipes presents no further problem. The cost of insulation is returned in full during the first few months' operation by virtue of heat saving alone, to say nothing of longer life of refractories through heat equalization, and improved furnace performance.

Insulation on Open-Hearth and Soaking Pit

The application of insulation to open-hearth furnaces is at present precluded by the fact that furnace operating temperatures so nearly approach the limiting temperatures of refractories ordinarily used in open-hearth construction. However, the insulation of the regenerator walls and arches is entirely feasible, and very substantial results are now being attained by this means on numerous installations.

Actual economies of operation are much greater than would be indicated by calculations based on increase in temperature of preheated gas and air, because suitable insulation properly applied also minimizes leakage through regenerator walls. New and old checker chambers are insulated according to slightly different specifications because of constructional features involved, but the general effect is the

same in either case, because the additional heat saving that results from better construction such as may be used on new regenerators is offset by lessened leakage through cracked walls of old regenerators.

Decreased fuel cost per ton of steel, increased speed of heats, diminished air leakage, increased flue temperature to waste heat boilers, and in general more satisfactory service result from the proper use of insulation on open-hearth regenerators. Some or all of these benefits are secured to a highly profitable degree in every installation, and the many successful installations have conclusively shown that the earlier fears as to possible ill effects on refractories were unfounded.

Soaking pit furnaces and regenerators benefit by insulation in much the same manner as the open-hearth, except that the lower furnace temperatures permit the application of insulation to the pits themselves. This results in more uniform soaking temperature in all portions of the furnace, assists in the elimination of rolling difficulties that result from uneven heating; and, by conserving the heat of previous charges, soaking time for all stock except cold high carbon ingots may be reduced without forcing the burners or danger of burning the steel.

The efficiency of the soaking pit, even including the regenerators is usually less than 10 per cent for uninsulated installation. This efficiency can be materially improved and actual cost of upkeep reduced by minimizing temperature variation within the refractories in an insulated furnace. A suitable insulation and casing applied to the soaking pit and to the regenerator walls with the elimination of some common brick, raises air temperature and reduces leakage, increases production, and cuts maintenance and operating costs.

Insulation on Rolling Mill Furnaces and Equipment

In intermediate furnaces which prepare stock for further rolling, such as billet, bloom and slab heating furnaces or sheet and pair furnaces, the matter of even

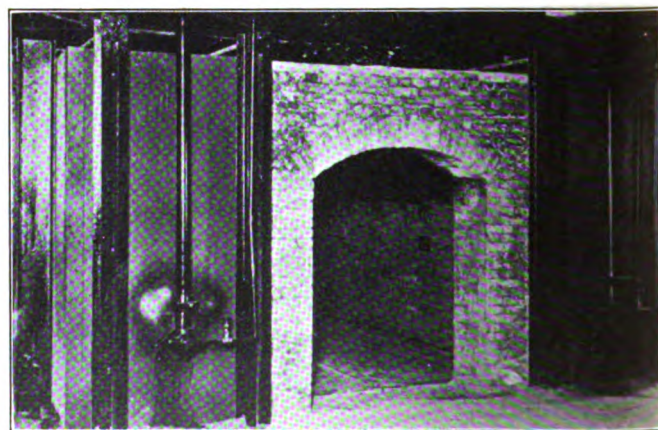


FIG. 9—Malleable iron annealing furnace insulation. Furnace constructed by the Carborundum Company of America at the plant of the Lehigh Foundries, Easton, Pa. Insulated with high temperature blocks.

heating and close temperature control is of more importance than in the soaking pit. Oxidizing conditions must be avoided in all parts of the furnace, since with light sections scaling wastes a very appreciable percentage of the steel and causes other difficulties by cementing the pieces together or by picking up bits

of brick and sand which scab the surface of the finished material.

Closer temperature control, more uniform heating and reduced air infiltration through the proper use of insulation in the furnace casing results in improved rolling conditions, less waste, a finer quality of product and better working conditions. Aside from this, the saving in heat radiation from a properly designed job is, by itself, quite sufficient to pay a highly satisfactory return on the insulation investment. There can be no justification, on a dollar and cents basis, for neglecting to provide adequate insulation in the construction of this class of equipment.

For many furnaces in this group, the conditions throughout the industry are so similar that standard insulation specifications have been made up covering materials and their application to the various designs. The use of such standards should be governed by determining how close the installation under consideration falls within the limits of practice for which the specification was drawn.

Annealing and Normalizing Furnaces

The gross wastage incidental to annealing and normalizing operations has been greatly curtailed in recent years by improvements in furnace design and methods of handling the work. Not least among the factors that are responsible for decreased rejections are the realization of the importance that insulation plays in evenly heating all parts of the furnace and its charge, and the attempt to abide by logical principles of design in preventing the flow of heat from those portions which tend to remain at lower than mean temperature. Here again are conditions where heat loss alone does not begin to explain the benefits that result from the proper use of suitable high temperature insulating blocks.

A typical example might be selected in the field of horizontal sheet normalizers so generally used in



FIG. 10—Kathner sheet normalizing furnace insulation. Furnace built by the Rust Engineering Company for the Newton Steel Company. The progress photograph shows block insulation being installed in heat zone top.

present day practice. The designer of a well known continuous sheet normalizer, after numerous experiments decided upon the use of high temperature, low shrinkage blocks of excellent insulating value, to be applied, where possible, in two layers, of thickness

specified in accordance with results of experiments. The insulating qualities of the material permitted the use of relatively thin sections to avoid bulkiness; the large size blocks hastened and decreased the cost of erection; and the double layer construction made possible the avoidance of through joints, with corresponding reduction in heat loss.

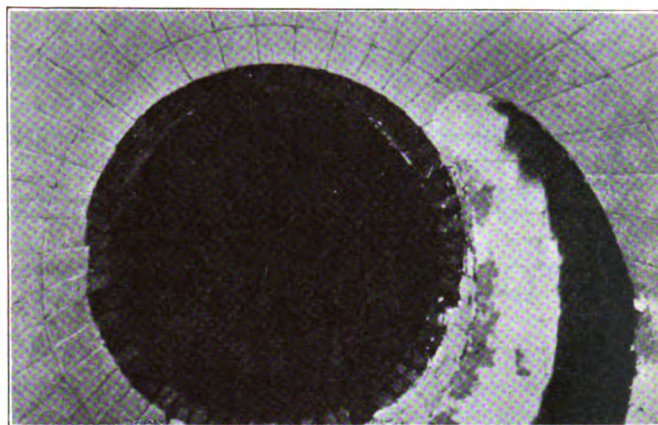


FIG. 11—Gas main insulation. Progress picture showing lining of cross-over being completed by installation of firebrick inside of high temperature insulating blocks which have been applied against the steel shell.

The results, which the designer ascribes in no small measure to the proper use of insulation, include superlative deep drawing qualities, fuel costs well below general practice because of heat conservation, increased speed, better texture by saving the bottom heat, thorough normalizing through uniformity of temperature, and a standard quality of product. Scratching and the necessity of roller leveling are reduced to a minimum, and there is a marked decrease in the number of seconds, even when operating without waster sheets.

Insulation in Producer Gas Mains

Insulated linings in producer gas mains also effect operating economies entirely apart from saving in sensible heat. By maintaining a high temperature in the gas, the insulation inhibits the deposition of tarry vapors resulting from the breaking down of unstable hydrocarbons, which subsequently condense on the firebrick lining. These vapors by remaining in suspension increase the calorific value of the gas at the furnaces, and as a correlary effect, the length of time between shut downs for burnout is materially increased.

The remarkable economies through heat conservation incidental to the proper use of insulation appear in producer mains as elsewhere. Heat loss through an insulated main lined with $4\frac{1}{2}$ in. of firebrick with gas temperature 1,400 deg. F. approximates 1,250 Btu. per square foot per hour. Insulated in accordance with a much used standard specification, this loss is reduced to 325 Btu. On the basis of heat worth \$0.25 per million Btu. and continuous operation, the saving corresponds to \$2.00 per square foot per year on an outlay of less than \$0.35 per square foot of insulating materials alone.

The implication is not made that just any sort of insulation is suitable for use in producer main lining. On the contrary, a careful preliminary study of the physical properties of the proposed insulation should

be made at temperatures comparable to that experienced under operating conditions. Facts and figures from past experience readily show the character of construction that is most successful.

Insulation on Other Steel Furnaces

On the long list of furnaces used in producing steel shapes and mill products, such as wire and pipe, a few have been made the subject of general discussion. By inference, the considerations advanced in connection with particular furnaces may be adapted to apply with varying precision to other furnaces where conditions determining the utility of suitable insulation are accordant.

At the risk of appearing to emphasize the obvious, the point should be brought out that the manufacture and application of furnace insulating materials has grown into a highly specialized industry. The importance of furnace insulation and casing design is second only to the design of the furnace itself, and this importance justifies the attention of every furnace builder or user.

The proper usage of insulation on any furnace is dependent upon a correct analysis of temperature conditions, the selection of the insulation best suited to meet all demands, and design based upon the judgment and experience of engineers well qualified to carry on this character of work.

Wrought Iron and the Puddling Process

High Grade Wrought Iron Is Still Manufactured for Certain Purposes for Which It Is Considered Superior to Any Other Material—Time Honored Processes Practically Unchanged

By GEORGE A. RICHARDSON*

It is not surprising in these days of constantly changing and improved methods of manufacture in the steel business, of mass and tonnage production on a tremendous scale, that a very general impression should prevail that the old time method of producing high grade wrought iron by the puddling process has been discarded. Many firmly believe, all talk to the contrary, that any product sold as wrought iron is some form of mild steel made in large quantities in an open hearth furnace.

The truth, however, is that not only is iron still made by this old time process, but an important source of supply is the Lebanon Plant of a corporation recognized as one of the most progressive steel making organizations in the country—the Bethlehem Steel Company.

It is a striking and most interesting thing to realize that, despite modern progress and the demands for lower costs and increased production, this organization finds it necessary to hold on to puddling and several other old time processes, simply because it has not been proved that new methods so far as developed, can make products of the same grade of excellence.

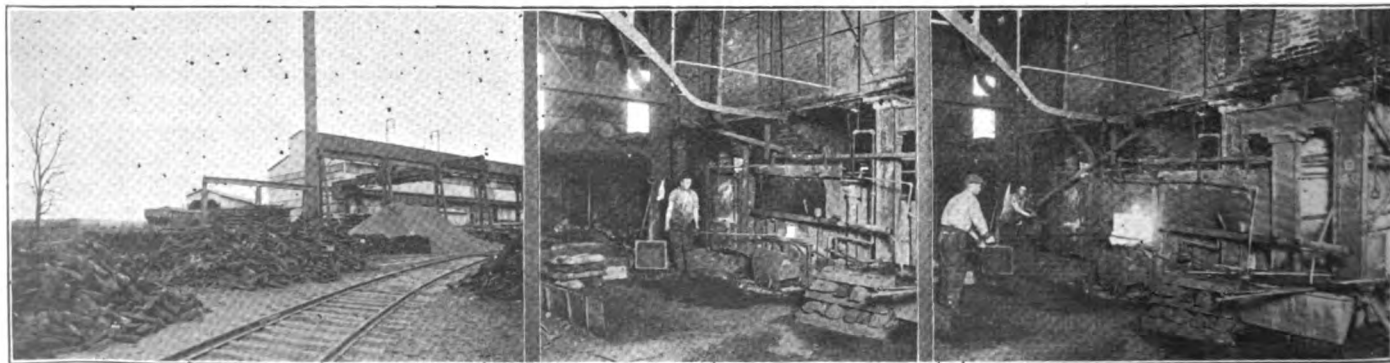
Lebanon Steel Company.

Few detailed descriptions of the puddling process have appeared in recent print. The facts that it has been handed down from earlier days and that manual labor and skill form such an important part, have resulted in driving it out of wide-spread use and thus have invested it with a certain air of mystery. Because of this situation a rather complete account will be of interest.

Definition of Wrought Iron

What is wrought iron? In the broadest sense, it is any iron that has been worked or can be worked and shaped. Its manufacture from the earliest times has required the expenditure of a great deal of hand work and hard labor. It can be hammered and forged at a red heat, and is not appreciably hardened by heating to redness and plunging into water.

Wrought iron is a product in a class by itself, differing from any in the steel industry, due to the fact that it is taken from the furnace in a solid condition ready to roll. It is particularly useful for certain purposes because of its physical structure, fibrous in nature, which gives it great toughness and the ability to stand up under severe vibratory and cooling and heating stresses. Furthermore, it is very resistant to corrosive action.



(Left)—Puddle mill stockyard. Ore for lining furnaces in pile in background. (Center)—Puddling furnace. Rabbling. (Right)—Taking ball from puddling furnace.

Wrought iron is unquestionably the first form in which iron was ever used, and the history of its manufacture therefore goes back many thousand years. Originally it was made by heating in direct contact with wood charcoal. Later pig iron was used but charcoal remained as a fuel because coke and coal contained too much sulphur. In 1784 the process of puddling was invented by Henry Cort. An improvement which followed was the development of a reverberatory furnace, which made possible the use of bituminous coal. A few later improvements followed, but in general it can be said that the essentials of the process have remained the same for more than 100 years.

Essentially the puddling process consists of the following steps which will be described in detail later. A small charge of pig iron is melted down under highly oxidizing conditions in a reverberatory furnace lined with iron ore. Carbon, manganese, silicon and the greater part of phosphorus and sulphur are oxidized and converted into a fluid slag with the aid of heat and oxide of iron. Particles of pure iron separate out in a pasty state, but not molten, because the melting point of pure iron is greater than the temperature of the furnace. These pasty iron particles coated with cinder are collected, and rolled into a spongy mass called a ball. The ball is then removed from the puddling furnace and subjected to various mechanical operations which squeeze out the slag and elongate the particles of iron into figures, a characteristic of the final physical structure.

Specifications for Iron

There are many individual specifications for wrought iron varying with the uses for which it is intended and the customers' own individual ideas. Only the highest grades are made at the Lebanon plant, of which the more important are the following:

Remelting Muck Bar.

Phosphorus	Not over 0.015%
Sulphur	Not over 0.015%
Carbon	Up to 0.20%
Usually copper free	

In muck bar for remelting into crucible steel, carbon will run from 0.06 per cent to 0.10 per cent.

Staybolt Iron—Bethlehem Special Muck.

	Approximately
Carbon	0.02%
Manganese, less than	0.05%
Silicon	0.10 to 0.14%
Phosphorus	0.125%
Sulphur	0.015%

Engine bolt iron has higher tensile strength than above and contains more phosphorus, sulphur and manganese.

Carbon	0.02 to 0.03%
Manganese, maximum	0.10%
Silicon	0.15%
Phosphorus	0.15%
Sulphur	0.017%

Copper can be added in a reasonable amount for special purposes such as chain iron and other iron exposed to corrosive action.

Wrought iron skelp is also made. Composition can be varied to meet customers' specifications.

These and other specifications make it necessary to carry a number of grades of pig iron in stock, as much of the ability to meet varying requirements lies in the use of the proper kinds of material at the start. Hence in the stockyard will be seen, in addition to the large pile of ore which is used for the lining of the furnaces, numerous small piles of pig iron, each with its own number representing a distinct grade. These are kept well separated so that there can be no chance of accidental mixing.

The actual manufacturing operations begin in the puddling plant. Here are located a mill for grinding the ore used for lining the furnaces; puddling furnaces; mono-rail tracks for transferring balls of iron to the squeezer; squeezer; muck bar mill; weigh scales; shears, etc.

The Furnaces

The puddling furnaces are small brick furnaces of the reverberatory type. The bottom is built on cast iron plates about 2 in. thick with an air space underneath for cooling. Those at Lebanon are considered to be the most modern type of hand-worked furnace. They use powdered coal as fuel.

Powdered coal as fuel was first used here for puddling in 1907, Lebanon being a pioneer. Its advantages are the saving in fuel, in time of heats, and the elimination of much of the hard work of firing.

The powdered coal is ground in a separate dust-house and conveyed to hoppers at the furnaces by means of screw conveyors. A second screw with variable feed takes the coal from the hopper to the burner where it is blown into the furnace with air at low pressure. The variable feed gives the puddler regulation as easily as with a gas valve.

A combustion chamber which will maintain sufficient heat to produce gasification and combustion before the flame strikes the cold stock is an essential feature. Otherwise the coal dust would tend to pile up on the stock, making melting difficult. In the combustion chamber much of the ash is deposited before it reaches the hearth where the material is being melted.

For the moment we will consider that we are starting in with a new furnace. This means that a bottom will have to be made and the sides lined, finely ground iron ore being used for the latter purpose.

The ore used is a lake ore known as "Beaver Fix." This is a naturally crumbly hematite ore and comes to the plant pretty well broken up. It is ground to a uniform fineness, water being added toward the end of the grinding period to produce a stiff mud.

A protective coating of hematite ore about 1½ in. thick is laid on the bottom plates. On this is thrown a ¼-in. layer of fine iron scale. Gradually, with heat on, the bottom is built up to a uniform thickness of about 2 in.

This accomplished, the firebrick sides and endwalls of the furnace are lined with the wet fix, the thickness averaging 6 in. to 8 in.

Once a furnace is in operation, work such as the above is done regularly at the end of a day's turn. Usually this is more in the nature of a repair job and consists of building up those parts that have been eaten away by the flame, or abraded by the manipulation of the charge.



(Left)—Starting ball in squeezer. (Center)—Taking bloom from squeezer. (Right)—Rolling muck bar.

After the bottom has been made and the walls lined, the furnace is ready for charging. Flux, which in this process is iron mill-scale, is first thrown into the furnace. From 150 to 300 lb. are charged and spread uniformly over the bottom. The amount will vary with the impurities in the pig and the required analysis of the finished product.

About 1,200 lb. of standard pig iron are charged next. Everything is now ready to proceed with the run which is divided into a number of periods which will be mentioned in their respective order.

As mentioned before, the puddling process is primarily nothing more than an oxidizing process. Hence

the first steps are for the purpose of insuring thorough oxidation of the non-ferrous elements, which of course require proper melting down; and the later steps are for the purpose of getting rid of these products of oxidation, which are transferred to the slag, thus putting the metal into the best possible physical condition.

Steps in the Puddling Process

The first period is known as the "melting down" period. At this stage of the process the temperature of the furnace is maintained as high as possible. After about 10 or 15 minutes, the puddler takes a "paddle," which is a long, square bar pointed on the end. With this he turns the pigs over and over, exposing the cool side, until they have been entirely melted down. The removal of the silicon commences at this time and continues through the next period.

The second period, known as the "clearing" period, is sometimes considered as part of the first. After the iron has thoroughly melted down it is "cleared" for about 10 minutes. Silicon continues to oxidize out and go into the slag so that at the end of the time nearly 90 per cent has been removed. Phosphorus also oxidizes and goes into the slag.

The clearing is accomplished by vigorously agitating the molten mass with a "rabble." This is a long, square bar with the end bent at right angles. It enables the puddler to work the material down to the level of the hearth.

"Clearing" is a very important part of the puddling process. If not done properly the iron will contain too much silicon and an excess of phosphorus and sulphur. At Lebanon very careful attention is given to insuring the proper clearing of the iron.

The next period is that known as "bringing on the boil." This sometimes is spoken of as being part of the actual boiling period. After the iron has been thoroughly cleared the damper on the furnace is lowered and the temperature reduced in order to permit of the thorough mixing of the molten iron and slag. Gradually the molten mass on the hearth swells and rises and this marks the actual beginning of the so-called boiling period.

"Boiling" is produced by the oxidation of the carbon in the metal, the products of these reactions being gases. When the entire charge has been melted and cleared it has become thoroughly mixed with oxides of iron. These are not only found in the linings of the furnace, but are also provided during the melting period from the iron scale thrown in before the pig iron is charged, and react on the metal. As a result



(Upper)—Muck bar piles. (Lower)—Box piles.
(Inset)—Slab piles.

of the combination of carbon with oxygen the temperature rises and the surface of the metal is agitated by the escape of CO gas generated by the reaction. This causes the swelling and appearance of boiling, from which the name "boiling period" is taken.

About 15 to 20 minutes now elapse, during which the puddler is actively employed in "rabbling" the charge to thoroughly incorporate the oxides and iron. Cinder which rises to the top trickles and is pulled out through the door in the front of the furnace, while the iron itself sinks to the bottom of the hearth. At this time practically all of the carbon and about 50 per cent of the sulphur is removed. There is little change in phosphorus or silicon content after clearing. The cinder runs down into a bogey and when solidified goes to the blast furnace as it is very rich in iron.

Towards the end of the boiling period, the boiling gradually subsides and the metal becomes stiffer and quieter. It is important that the temperature be properly maintained at this time. The carbon is now below 1 per cent.

Fining and Balling

The next period is known as the "fining stage," although in the mill it is usually spoken of as the time for digging and turning, i.e., the iron "comes to nature." At the end of the boil the whole charge sinks, and, as already indicated, has begun to assume a pasty condition, in which some of the cinder tends to separate out from the iron.

The puddler now takes a "rabble" and works the metal very thoroughly. The remainder of the carbon and manganese are oxidized and also some of the phosphorus. As the pasty mass is worked it stiffens more and more and is broken up. Masses of metal begin to protrude above the cinder, showing that the iron has "come to nature." It is now turned over three times, first towards the bridge wall, then towards the flue and back again towards the bridge wall, in order to expose the under sides and thoroughly heat every particle uniformly to the desired temperature, which at this time will be from 2,000 to 2,500 deg. F.

The balling stage follows. The temperature is brought up as high as possible to obtain a good welding heat and make a fluid slag that will work out in the squeezer. About 20 minutes are required. The pasty, spongy mass of metal is divided into six nearly equal parts, these being formed with the puddler's bar. Each lump or ball will weigh about 200 lb.

After the balls have been made, they are subjected to welding heat for about five minutes, after which they are drawn one by one from the furnace and carried to the squeezer with the aid of large tongs suspended on a mono-rail.

One squeezer serves all puddling mill furnaces, and as they complete their runs at approximately the same time it is in continuous operation only for a short interval.

The Squeezer

The squeezer consists of two parts. First, a large circular corrugated casing. In this is placed out of center a corrugated circular drum, which revolves. The balls enter at the large end and roll around the periphery, being gradually squeezed in an ever-narrowing space; and come out at the small end as a bloom about $7\frac{1}{2}$ in. in diameter by 18 in. long. In squeezing a large part of the slag is eliminated from the pasty mass.

The bloom is rolled down into a flat bar known as muck-bar on a three high muck-bar mill. Several sizes of muck bar are made, ranging from 3 to 6 in. in width and about $\frac{1}{2}$ to $\frac{3}{4}$ in. in thickness. From the mill they travel on a conveyor to scales for weighing and thence to shears where they are cut up into shorter lengths for piling for the flat or square "breakdowns."

First Break-Down

In piling for the first "break-down" what is known as a "muck-bar pile" is formed; in other words, a number of the sheared pieces of muck-bar, depending upon the size and section to be rolled, are piled one on top of the other, wired together and the pile is charged into a furnace and brought to welding heat. The pile is rolled down into a flat, sometimes called



Rolling bars.

slab, or square section, on a hand-mill. This is a preliminary operation and the metal has not yet been worked down into the best possible physical condition. Another rolling operation must follow.

The flat or square bars which have been rolled in the first break-down operation are in turn sheared into short lengths, and piles are formed for the final rolling. At this point the type of pile used will depend upon the purpose for which the finished product is to be used.

Piling

Iron that is to be used for staybolts is usually box-piled. In other words, four flat slabs of break-down are taken and form the sides of a square box, the middle of which is filled with bars having a square cross section. This box-pile, held together with thin iron clamps, is brought up to welding temperature in a heating furnace and then rolled down in a 12-in. hand mill to the desired size. The reason for using this form of a pile is that a fibrous structure is obtained which withstands vibration, a very important consideration for staybolts.

Engine bolt iron may be rolled from a box-pile, but some customers specify a slab pile. In the latter case the pile is built up exclusively from flat bars, or slabs, and subsequent operations are the same as in the case of the box-pile material. The reason for specifying this form, if at all, is that some suppose more slag is worked out of the metal as it has a chance to escape at the sides.

One of the very interesting things about iron is that, in reduced form, the finished bars retain the same type of structure as that of the original pile. In other words, if a cross section is etched, a bar which has been rolled from a box-pile will show all of the individual parts in their relative locations, while in a bar

rolled from a slab pile, the metal can be seen in the form of flat layers.

After rolling the bars pass out upon the hot-bed where they are straightened and allowed to cool. They are then sheared to length and taken to the iron warehouse, from which point they will be transferred to the finishing department or to the customer, as called for.

There are two things that should be stressed in speaking of the manufacture of high grade puddled iron. One is the precautions taken to insure that no steel be mixed with the iron. Users fear a possibility of this in a plant which is also rolling steel. Such a condition, however, cannot occur at Lebanon. First, the puddle mill and rolling mills for puddled iron are separate from the steel-rolling end of the plant. Nothing but iron in the form of pig, ore, or other oxide of iron and flux enters the puddle furnace. In order to insure uniform high grade of the iron produced, even busheling has long since been abandoned. Thus, only one grade of iron is produced. Then after rolling the iron is stored in an iron warehouse, which is a unit entirely separate from the steel warehouse.

The other very important factor is laboratory facilities. There is probably no puddled iron plant in the country that has more complete laboratory facilities and that more carefully tests the material being made. Physical tests are made on the finished bars and every heat of muck bar produced is chemically analyzed. The size of the Lebanon layout is such that a considerable number of high grade technicians can be maintained.

Manufacture of Staybolts

The most important steps in the metallurgy of engine bolts, staybolts and other wrought iron products, have been touched upon. Care and proper equipment are just as important, however, in the finishing operations, which will be briefly outlined.

In the making of staybolts and engine bolts, bars from the iron storehouse are straightened in roll straighteners and sheared to length.

All material which requires drilling is pointed, either simple flat facing, or beveled edge pointing being used, as specified. Staybolt material then goes to the six modern deep-hole drillers in the finishing department. On these, 3/16-in. or 7/32-in. holes are drilled to a maximum length of 36 in. The manufacturers consider a 7/32-in. hole the better size to specify.

The exact sequence of the finishing operations will of course depend on the specifications. For instance, if square ends are not required, the bars are threaded the entire length, then cut off on a turret lathe and drilled in the drilling machines.

In the drilling operations, hollow drills are used, the drill point being welded on a hollow rod. Oil at 800/900 lb. pressure is pumped through. The pressure can be raised to 1,800 lb. The drill feed will vary from 1½ in. per minute with a 3/16-in. hole to 1¾ in. for a 7/32-in. hole. The use of a lead screw gives accurate centering at both ends.

Facilities are provided for making all required sizes of engine bolts and staybolts to any reasonable specifications.

Important, in addition to equipment, in the manufacture of engine bolts and staybolts is the close supervision and care. There is both a factory inspection and a warehouse final inspection.

Dovel Type Blast Furnace Put on Test

(Continued from page 1558)

Average Ore Analysis of Ores Used

Silica	10.82
Alumina	3.02
Metallic iron	40.57
Insoluble	12.95
Cabronates of lime	21.74
Phosphorus	.34
Manganese	.41
Fe ₂ O ₃	56.79

Flue Dust Analysis

From dust catcher

Carbon	CO ₂	Iron
29.60	5.28	21.80

From Gas Mains to Stoves

(May 1, 1928)

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	Cyanide
16.28	14.35	14.85	8.50	4.37	8.32	5.80	3.35

Carbonaceous matter

21.50

Sulphates

1.96

Screen Test on Flue Dust Caught During 6-Day Test

	Per cent
Over 10 mesh	1.20
10 to 20 mesh	2.80
20 to 40 mesh	2.20
40 to 60 mesh	33.00
60 to 80 mesh	6.50
80 to 100 mesh	19.80
100 to 200 mesh	12.10
Under 200 mesh	4.40

Chain Transfer Tables for Blooms

(Continued from page 1559)

collar on the shaft that is held against the hub by the outer block.

Operating Control

The whole operation, not only of the transfer table, but of the two runout tables connected with it is controlled from one point near the juncture of the table with the shear runout table. Thus it is possible for one operator to route blooms coming from the shear to any one of three destinations, according to the treatment they require. Those intended for rolling without treatment can be sent directly to the rolling mill by a live roll table which crosses the transfer table to a point about 15 ft. from its beginning. Those which require reheating travel to a second live roll table located at the extreme end of the transfer table, which carries them to the entrance of the reheating furnaces. And those which are to be thermally conditioned, or chipped are carried over the end of the transfer table, and deposited in cradles in which they are carried by cranes to their ultimate destinations. The proper handling of blooms is facilitated by the fact that the operator has a clear view of the whole table from his control station, and can act immediately in accordance with the demands of any situation that may arise.

Modern Furnaces for Normalizing Sheets

A Description Is Here Given of Equipment Lately Installed for
the Continuous Annealing of Sheet Steel—Metal-
lurgical Features Are Fully Discussed

"AUTOSHEET"

AT the plant of one of the leading sheet steel manufacturers another modern type normalizing furnace* was lighted, which marks a still further progressive step by this particular sheet mill toward serving the automobile trade and allied industries in producing high quality sheets. This installation including the latest improvements in design is worthy of descriptive comment inasmuch as it reflects the foresight of this company in demanding such equipment as will produce sheets of uniform quality.

The writer was lately privileged to visit the plant and witnessed the operation and control of this normalizing furnace and observed the quality of the sheets thus treated. The conclusions are based upon an impartial comparison of the results with practice as carried out in normalizers of earlier design.

Advantages of Normalizing

Before entering into a description of the mechanical features of this furnace we shall state the purpose for which the continuous annealing of sheet steel is done. While continuous annealing is a rather broad term we are confined in this case to the continuous normalizing of sheet steel.

The steel passes through this long narrow furnace, is heated to a temperature above its critical range and is then slowly cooled in the cooling zone. Heating it at above the critical range allows for a complete rearrangement of the structure. If the heating is long and high enough we relieve the strains set up in hot mill rolling and allow good equi-axing of the crystals, or the new grain growth. The size of crystals for various reasons should be kept quite small. As soon as this new growth starts we must be ready to enter the cooling zone and prevent its further growth. This brings in the question of how fast or at what speed we must send the steel through the furnace, which is entirely dependent on the temperatures of the heat zone and the length of the heating and cooling section.

*Constructed by Rust Engineering Company of Pittsburgh, Pa., under Kathner patents controlled by Duraloy Company of Pittsburgh, Pa.

The furnace which we are to describe is 155 ft. long and is divided into three primary zones namely the preheat, soaking and cooling zones. The preheat and soaking zones are approximately 75 ft. long thus allowing 80 ft. for the cooling section. The preheat and soaking sections are easily distinguished from the cooling section in that the roof is considerably higher than the roof on the cooling zone.

The burners, 20 on each side, are about a foot above the sheet and are equally spaced extending from the end of the soaking zone to within about 15 ft. from the charging end of the furnace. They burn oil through inducing burners with steam under high pressure as the atomizing agent. However it is possible on short notice to switch over to gas through the medium of an auxiliary set of burners should oil not be available.

At this point we have observed merely the general outside appearance of the furnace and in doing so have noticed that the furnace is built in sections. These sections appear to be about 5 ft. long and form the two walls and the roof in one casting with joints to allow for the thermal expansion. This sectional type is a decided advantage for in the event that a shaft needs to be changed the length of shutdown is negligible as only that section in which the bad shaft lies needs to be removed. A good example of this particular feature has been cited in which a broken shaft was replaced by removing the section (which includes the side wall and roof) in one operation, the broken shaft as a second operation and the replacement of a new shaft and the section as the third and last operation. It has been stated that a change of this nature can be made in less than an hour, during which time it was necessary to turn off the burners only in that section of the furnace, allowing for a quick pick up to normal operating temperatures.

It might be imagined that a furnace of this sectional construction would suck air and thus scale the sheets, but a closer examination of the furnace shows that a plastic clay fills the short expansion space between the sections thus preventing air from entering.

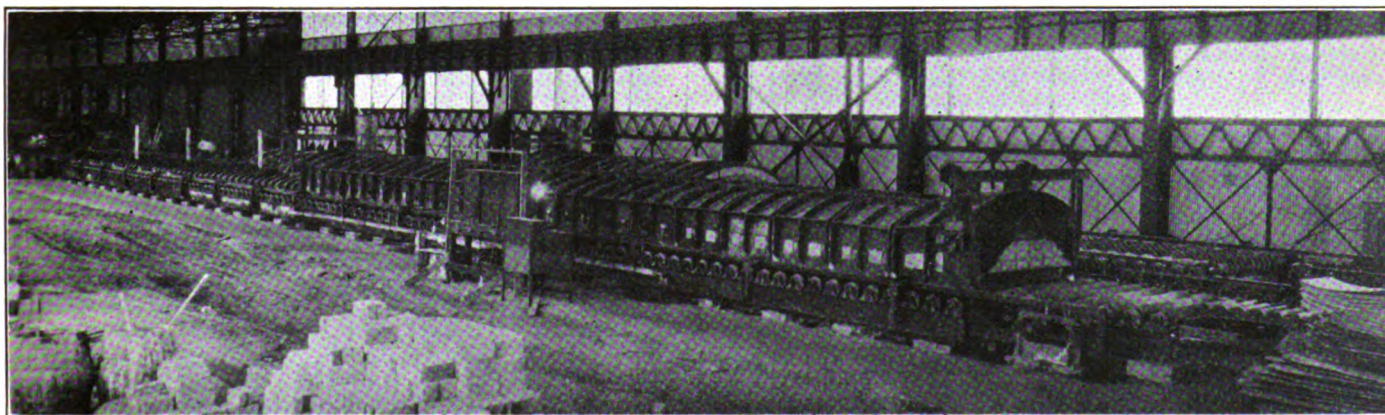


FIG. 1—General view of 155-ft. normalizer for continuously annealing sheet steel.

This closer scrutiny of the outside of the furnace brings to our attention the fact that while the pyrometers are showing temperatures between 1700-1900 deg. F. in the preheat and soaking zones the furnace walls are radiating much less heat than is anticipated.

This probably serves as a good example when we understand that this is perhaps one of the most important points in the advantage of this normalizer, namely, the insulation of the heat. So thoroughly insulated are the walls, roof, shafts and even the bottom that the fuel consumption is remarkably low when one considers the high heat to which the sheets are subjected.

From a metallurgical standpoint the writer can appreciate this fact in that there is a more uniform heat resulting from this thorough insulation thus giving a consistent furnace heat, from a point well below

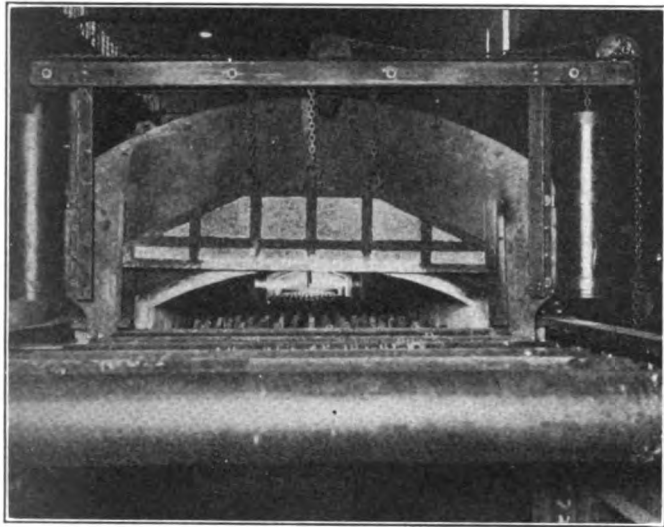


FIG. 2—View of charging end.

the sheet level to the roof. This in turn gives the sheet a more uniform heating resulting in uniform grains and thus a uniform product. This is indeed a simple deduction but for many years the only method considered advisable for annealing sheets was the box furnace which today cannot compete with continuous normalizing for uniform heating and resulting sheet structure. The simple but effective answer is insulation resulting in a good product at a low rate of fuel consumption.

To sustain these arguments the writer observed pyrometer readings which not only indicated the roof temperatures but the heat at the bottom of the furnace as well. In one part of the preheating zone the difference between the thermocouple 1 ft. under the sheet and a couple 1 ft. over the sheet with both in line with each other was only 40 deg. F. The same condition existed in the soaking zone where the difference was 50 deg. F. We would say that is a uniform heat considering that the burners are above the sheets and that the sheets will tend to absorb most of the heat if the burners are carefully regulated.

Speaking of pyrometers we are impressed with the fact that if pyrometers mean good heat control and good heat control means good sheets this installation should mean an excellent product. In the preheat and soaking zones there are at least eight couples with six of these eight in the roof, the first one being about 25 ft. from the charging end and the other five about

10 ft. apart, the last being at the end of the soaking zone. The other two of the eight lie at two strategic points on the bottom of the furnace under the sheets and as mentioned above show very little difference in temperature from the couples opposite them in the roof.

In the cooling zone we have four roof couples about 20 ft. apart thus taking in the maximum and minimum temperatures of the entire cooling range. The cooling rate according to these pyrometers shows an average drop of about 75 deg. F. for every 10 ft. toward the exit end.

Having observed the important features which make up the outside of this normalizer we next inspected, so far as possible the inside, noting the mechanical means of conveying the sheets through the furnace.

A glance into the charging end shows us that the sheets will travel along on discs which in turn are attached to shafts on 15 in. centers. This close spacing of the shafts makes it necessary to stagger the discs which means a possible nine discs on every other shaft with those shafts between carrying eight discs, the number varying with the width of the furnace.

This particular furnace is 84 in. wide which means that a sheet, or sheets side by side, to the width of 64 in. can be accommodated. This is indeed a feature not to be overlooked for the automobile trade is demanding wider sheets in order to blank larger sections of body parts where possibly two blanks were formerly used. These wider sheets, so much in demand, will soon revolutionize sheet mill equipment. It will mean wider hot mill rolls, larger pickling tanks, bigger annealing boxes and subsequently larger box annealing furnaces. In the case of normalizing this furnace has anticipated this change and is prepared to normalize sheets of the widest width that can be commercially rolled and handled by men.

In the event that the length of sheets do not exceed the width capacity of the furnace they may be turned and fed in crosswise which, as can well be imagined, means using practically all the available disc space without impeding the circulation of heat. This results in a high efficiency from the furnace and greater tonnage output.

Discs and Shafts

At this point let us examine more closely the shaft on which the discs are mounted. These shafts are of heavy seamless steel tubes on which the alloy discs are mounted approximately 8 in. apart. The discs are cast integral with a long hub. These hubs interlock end to end and are materially larger than the shaft which carries them. The hubs are centered and supported on this shaft by three radial fingers. The space between the inside wall of the hub and the wall of the shaft is filled with a heat insulating material. This insulation protects the shaft, confines the heat to the sheet and aids the insulation given to the walls, roof and bottom as previously described.

The driving mechanism for these shafts is worthy of comment for in a furnace 155 ft. long it means an even and constant rotation of 155 shafts all carrying a heavy load of sheets. On the end of each shaft is mounted a sprocket over which runs a continuous chain of the roller type, the return chain going back along a channel just under the sprockets. This chain in turn is driven by a main drive sprocket located at about the central section of the furnace.

This particular installation carries two separate drives, one driving the shafts in the cooling zone while the other drives the shafts of the heating zone. The main sprocket for each drive is then connected to a spur gear speed reducer driven by a variable speed motor which allows us to send the sheets through the furnace at a speed which will give us the grain structure desired by the metallurgical department. The two drives are synchronized and connected.

In addition to driving these 155 shafts the rolls of the feed and delivery tables at the charging and exit ends must also be driven which is done by an auxiliary chain connected to these drives. It is indeed a remarkable sight to see a drive of this nature turning all these shafts each weighing about 900 lbs. without considering the weight of sheets transversing the furnace and the charging table rolls.

Thermal and Structural Changes in Furnace

Now that we have described fairly much in detail the outstanding mechanical features of this furnace both inside and out let us follow the changes both structural and thermal as the sheets progress through the furnace.

First the hot mill sheets are brought to the charging end of the furnace on buggies. These piles of sheets are called "lifts" and average around 15,000 lbs. in weight. Two men, the feeder and his helper, place a waster or dummy sheet on the charging table and onto this waster sheet two or three sheets from the lift are placed, depending on their gage and size. The sheets are then pushed along this table and enter the first or preheating zone of the furnace. The sheets are now in a temperature of about 1400 deg. F. which of course they immediately start to absorb.

In order to prevent the scaling of sheets, a slightly incomplete combustion of the oil is maintained with the resulting gases of such a volume that the pressure thus exerted prevents any suction of air into the furnace.

The burned and unburned gases together with the resulting heat from burners are entering the furnace through large ports in the insulating wall with such

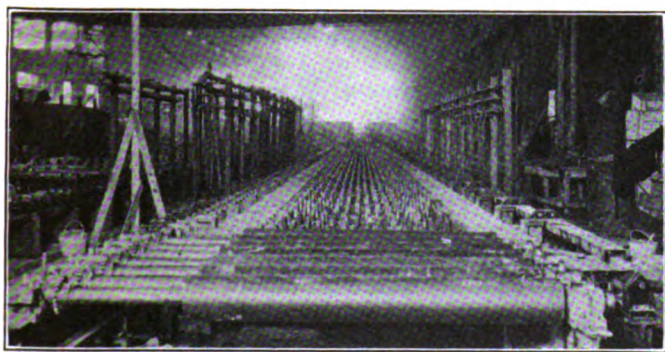


FIG. 3—View of discs in heat zone.

force that they mix with the gas and heat of adjacent burners and distribute an even heat to the furnace. The gases and heat travel back to the charging end and thus maintain this approximate temperature of 1400 deg. F. at this point. Due to the fact that the sheet is cold and the furnace is hot the absorption rate is very rapid, gradually tapering off as we reach the soaking zone. At a point about 25 ft. from the charging end of the furnace the sheet is just under our first thermocouple which reads about 1700 deg. F. and,

judging by the appearance of the sheet at this point, it is fairly close to its critical range.

The thermocouples are then every 10 ft. apart for the remainder of the preheat and soaking zones. At a point 45 ft. away from the charging end the sheet has passed under the third couple which registers close to 1800 deg. F. and we are safe in saying that under the proper conditions of heating and speed the sheet is now above its critical range and its main constituents, which are pearlite and ferrite, have been allotropically

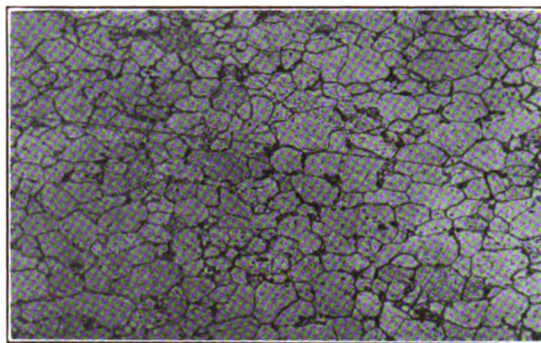


FIG. 4—Microstructure of typical steel out of this normalizer, X100.

changed with the carbon dissolved in gamma iron which we call austenite. From this point on the sheet is in the soaking zone proper. A soft soaking heat is maintained in this section of the furnace and the four roof couples which come within this zone show little variation. Due to the nature of the heat in this furnace and the soaking effect it has on the sheet it is to be expected that this might well be called the soaking zone. In this heating area we must carefully maintain speed and temperature in order that the sheet may be ready to enter the cooling zone as soon as all hot mill strain has been relieved from the sheet and the new grain growth started. As previously mentioned we want a fairly small grain and once determined we must prohibit its further growth by leading it into the cooling zone.

Between the soaking and cooling zones is a door made of an alloy casting filled with high heat resisting brick. This door is adjustable up or down and by means of a stack or bleeder close to it in the roof of the soaking zone, the temperature of the cooling zone is correctly maintained. This zone must also carry a reducing atmosphere in order to prevent a scaling of the sheet. Due to the flow of material through the furnace the gases are partially drawn and flow back into the cooling area thus maintaining this reducing atmosphere.

This reducing atmosphere in turn is carefully maintained through the medium of the lower roof level of the cooling zone and the adjustable door previously mentioned. The sheet then enters the cooling zone relieved of hot mill strains and having a new grain growth which is retained in most any size as the metallurgical department sees fit. Thermocouples located in the roof show an approximately 400 deg. F. drop in temperature between the end of the soaking and about 15 to 20 ft. in the cooling area. This means a proportionate drop in the sheet temperature which in turn indicates that the steel is now below its critical range. The carbon no longer can be dissolved and the cooling is so rapid that the same structure that we had

(Continued on page 1578)

Recent Observations on Some European Iron and Steel Conditions*

Continuing Description of German Blast Furnace Practice
with Comments on Coke Oven Operation and German
Open-Hearth Methods and Rail Mill Practice

By C. A. MEISSNER†

PART II

BUT little scrap is charged in German furnaces, because of difficulties with the bucket tops, generally used. Besides it is needed for open-hearth furnaces. Screening of ores is not practiced in Germany as far as could be learned. Volklingen Plant at Saarbrücken, France, working on minette ores with 32 to 35 per cent iron content, has been screening for 1½ years, sintering the fines with flue dust, coke dust and mill scale. Other plants in the Luxemburg region are contemplating doing this soon.

Belt transmission of ores is nowhere in use. They see no objection to it, however. Transmission of all sorts of materials with cable buckets is very generally used all over Europe.

Crushing of coke is not generally practiced in Germany. The Vulkan plant is crushing to 1½ to 2¾ in. screening out the walnut size for domestic and the breeze for sinter. They are obtaining good results and other plants are now starting to do this.

Top Filling—At Hamborn Works, Neeland bucket type filling is used on all furnaces and is common throughout Europe on the larger furnaces. A distributing cone with central distributing tube is set on brackets below the bell. The best working clearance between cone and furnace lining has been found to be 29½ in. They have tried leaving out the central distributing tubes but results were unsatisfactory so they put them in again. Ordinarily, cones and tubes will have to be replaced once during a campaign, or when the furnace has made about 600,000 tons of iron.

These central distributing tubes are not gas off-takes in the modern furnaces but merely serve to distribute the charge; the gas goes through them and the materials around the tubes, and the gas then comes down through two or more side off-takes similar to our own construction. Wherever the Neeland bucket is used, central gas off-takes become impossible. Where hand skip or cable buckets are used, central tube gas off-takes can be used. The latest modern skip furnaces, however, have two or more side off-takes.

A charge consists of one bucket of coke weighing 4 tons, and one bucket containing ore, sinter, open-hearth slag, limestone, etc. Each kind of ore and other material is laid in a layer by weight, the total contents of second bucket being about 12 tons.

In looking over these figures keep in mind the large bosh diameter of the small furnaces and their consequent large cubic capacity, which is equivalent to our 18-ft. furnaces, some of which are making big tonnages on our soft and fine materials. At Gelsen-

kirchen a straight bosh furnace is being built, but there is much doubt as to its success, the feeling being that the stock will lie too heavy on the molten contents of the hearth.

Vereinigte Stahlwerke, Hamborn Plant,
Near Düsseldorf, Germany.

	Old No. 3 furnace		New No. 8 furnace	
Height	87 ft.	11 in.	95 ft.	3¾ in.
Hearth diameter	16 ft.	5 in.	21 ft.	4 in.
Bosh diameter	24 ft.	7¼ in.	24 ft.	7¼ in.
Bosh angle	74 deg.	29 min.	82 deg.	6 min.
Inwall angle	85 deg.	16 min.	86 deg.	20 min.
Bosh height	13 ft.	5½ in.	13 ft.	5½ in.
Cubical capacity	23,710 cu. ft.		29,264 cu. ft.	
Diameter distributing cone	9 ft.	4 in.	12 ft.	1¾ in.
Diameter distributing central tube	6 ft.	6¾ in.	7 ft.	8¾ in.
Inside diameter furnace top	14 ft.	5¾ in.	16 ft.	1 in.
Thickness inwall lining ...	3 ft.	3¾ in.	3 ft.	3¾ in.

Casting—Hamborn furnaces are cast every two to two and one-half hours, because of small hearth and large tonnage.

Production—At Hamborn furnaces, daily average production through a year on 16-ft. 5-in. hearth furnaces, in good condition and with good ore mixture, has been as high as 835 tons. This they attribute largely to the open nature of the burden. Daily averages for a month are sometimes as high as 850 tons and they have made as high as 920 tons daily for a month's run. Productions of 950 to 1000 tons are occasionally made for a day or two, but not over any period of time. The present daily average production, because of poor ore mixture resulting from the Swedish mine strike, is 700 tons per furnace. Average production for a campaign is about 1,200,000 tons. Varying amounts of sinter are used.

On good ore mixture slag volume is about 1100 lbs. per ton of iron. On present poor ore mixture about 1760 lbs. per ton of iron.

On good ore mixture the coke rate is from 1716 to 1870 lbs. per ton on larger furnaces, depending of course on age of furnace.

Blast temperature is generally 950 to 1100 deg. F. throughout Germany, higher heats slow the furnaces down too much. Hamborn is using 1200 deg. F. However, one plant at Saarbrücken, France, expects to go to 1550 deg. F. on minette ores and sinter. The general feeling is that there is no limit to stove heat, except what the furnace will take without slowing down.

Heating surface per stove on the new Hamborn furnace is 102,000 sq. ft. Four two-pass side-combustion chamber stoves, with square checkers having 2¾-in. brick and 3½-in. holes, are being constructed.

*Abstract of paper before the American Iron and Steel Institute, New York, October 26, 1928.

†Chairman, Coke, Blast Furnace and Open-Hearth Committee, United States Steel Corporation, New York.

Top temperatures run from 300 to 480 deg. F.

Average wind on 16-ft. 5-in. furnaces is 49,600 to 59,000 cu. ft. per min. New furnace will blow 71,000 to 75,000 cu. ft. per min. Gas engines are used exclusively at this plant for blowing and electric generators. The high first cost of gas engines is weakening their position in Germany. New blast furnaces at Essen are installing 90,000 cu. ft. per min. turbo-blowers.

Blast pressure at the Hamborn plant is about 14½ lbs. per sq. in. Ordinary tuyeres are used, but patented Venturi type tuyeres will be tried.

Construction—Inwall: Large fire brick blocks with open cast iron water-cooled boxes set between them. The blocks are special shapes, about 9 x 5 x 24 in. in size. Steel bands reinforce the whole.

Hearth and Bosh—Bosh is steel plate with spray cooling. Open end cast iron water-cooled boxes are set into the brick work through the steel plate. Hearth jackets were formerly of steel plate, but cast segments, 4⅝ in. thick, are now being used. They are spray cooled and entirely exposed. Breakouts in the past have averaged one a year for a seven-furnace plant, but they expect the cast steel jackets will lessen this trouble. Carbon brick are used to line bosh and hearth and for bottom blocks. We were told that use of carbon brick is not general in Germany, the majority of plants using fire brick. The carbon brick have 95 per cent carbon and must be very hard pressed, their service depending largely on the firm manufacturing them. High alumina brick seem to be little known.

Sintering—So far as could be learned, no plants in Germany are screening their ore and sintering the fines. They are, however, using a great deal of sinter, made from the following mixtures:

Straight Flue Dust—Sintering of flue dust is done by Dwight-Lloyd machines or rotary kilns. Carbon, 10 per cent; iron, 42 to 45 per cent. Sinter contains 50 per cent iron. Up to 30 per cent of blast furnace charge has been used with good results, and more would be used if available. Stock pile flue dust is briquetted.

Flue dust and Swedish concentrates are mixed and sintered at many plants, giving a very good product containing about 66 per cent iron. Some plants also add coke breeze. Six and one-half per cent carbon is about the lowest that will give good sinter.

Flue dust and Bluebilly or purple ore are mixed extensively as the latter is cheap and runs from 40 to 55 per cent Fe. Meiderich works has a two-strand, 39⅜ in. by 82 ft. Dwight-Lloyd machine using this mixture. The charge contains 45 per cent Fe, 6½ per cent C, 13 per cent moisture and is laid on a ¾-in. crushed limestone bed to protect the pans. Blast furnace gas is used for ignition. The furnaces at this plant have used up to 50 per cent sinter with good results.

We were told that Duisberg Kupferhutte has a small 250-ton furnace using 100 per cent sinter made from pyrites and giving good results. The special iron made here furnishes practically all the keys for doors, locks, etc., made in Germany.

Flue dust, coke breeze, spathic ore, Swedish concentrates and bluebilly have been used in various mixtures as available at Bochumer furnaces and the sinter is well liked by furnacemen.

Blast Furnace Gas—Heat value from 106 to 112 Btu. per cu. ft. It is used very extensively for the following purposes:

- 1—Stoves.
- 2—Gas engines for blowing and generating.
- 3—Coke oven heating.
- 4—Open-hearth heating, mixed with by-product gas.
- 5—Boilers, alone and over stoker feeders.
- 6—Soaking pits, alone or mixed with by-product gas.
- 7—Heating furnaces, alone or mixed with by-product gas.
- 8—Sintering machine ignition.

No special stove burners are used at the large Duisburg plants visited.

For open-hearth heating, blast furnace gas alone has been tried, but found too weak, so by-product gas, in ratio commonly of 1 of by-product to 2 of blast furnace, is turned into the blast furnace gas main just before checkers.

For soaking pits Hamborn uses straight blast furnace gas with regenerators and combustion chamber, or mixed gas burned with cold air.

For heating furnaces the situation is the same as for soaking pits. The first cost of regenerators is high, but where by-product gas can be sold to the cities it pays to make the blast furnace gas go as far as possible.

The general feeling is that gas should be cleaned to .1 or .15 grain per cu. ft. for boilers. Hamborn furnaces each have a large dust catcher which cleans from 15 to 4½ grains per cu. ft., a small catcher which cleans from 4½ to 2½ grains per cu. ft., Zschoke washers which clean from 2½ to .15 grain per cu. ft., and Theissen washers cleaning to .025 grain per cu. ft. Gas is stored in a 10,600,000 cu. ft. M. A. N. tar seal gas holder, the largest in Europe. Theissen washers are still generally used in Germany for gas engine gas.

Sludge is usually deposited in settling basins and removed with bucket cranes. Very little seems to have been done with thickeners.

Blowers—Essen plants of Krupp and Mannesmann are installing turbo-blowers. They figure that the first cost of gas engines is too high.

Slag—Slag brick are extensively used throughout Germany for house building. One common method of manufacture is to mix granulated slag with hydraulic lime, press the brick, put them into a cylinder where high pressure steam is turned in for some time, then take them out and cool.

Granulated slag is also hauled in empty coal cars back to the mines, mixed with sand and run into old workings to prevent falling in of roofs. Water is used to carry it through steel pipes, and tile pipes are used at the bends as they have been found to wear better than steel. Many coal mines are anxious to get this slag, and also solid slag, which latter they carry into the mines on belt conveyors.

Electrical Precipitation of Flue Dust

The cleaning of blast furnace gas by electrical precipitation is arousing a great deal of interest throughout Central Europe. Among the reasons given for this interest are the following:

- 1—Power consumption of electric cleaning is about one-tenth that of wet washing.
- 2—Cost of sludge disposal from wet washers is high.

3—Difficulty of waste water disposition is serious in some sections.

4—Shortage of water at some plants makes wet washing objectionable.

5—Several plants are putting in turbo-blowers and so do not need such clean gas as would be required for gas engines.

6—The saving of sensible heat, even after gas is partially cooled in primary coolers, is considered to more than offset the extra moisture carried by the gas.

Efforts to electrically clean hot gas have met with little success abroad. The feeling is general that the economical unit is one which has a thermostatically controller spray tower preceding it, so that the gas to be cleaned will have a uniform temperature, ranging from 140 to 210 deg. F. in different installations. The reduced volume of the cooled gas makes possible a smaller unit, and the uniform temperature permits much cheaper construction than would be possible if the high temperatures during slips had to be guarded against. It has also been established that, for a given cleanliness of gas, higher gas temperature necessitates lower velocity through the cleaner. This condition would therefore call for a considerably larger cleaner for gas at, say, 400 deg. F. than is needed for gas under 200 deg. F.

The feeling exists generally that the advantages of high sensible heat and low moisture content of hot gas are more than offset by the money saved in building the smaller, more efficient and more cheaply constructed unit using cooled gas.

The primary cooling towers are provided with atomizing spray nozzles which put just enough water into the gas to cool it to the desired temperature. This water is all carried over into the cleaner as a vapor and the thermostatic control of the spray nozzles is such that the gas will be some 20 to 25 degrees above its dew point. The water added will raise the moisture content of the gas from 20 or 25 grains per cu. ft. to 40 or 50 grains per cu. ft. If the gas is to be used in gas engines a subsequent cooling to reduce this moisture to about 10 grains per cu. ft. is necessary, but if the gas is going to boilers and stoves the expense of this secondary cooling is not felt justifiable by plant engineers.

The Lurgi Company is installing at the Lubeck plant in Germany, cleaners of the horizontal flow, plate type recently developed by the Research Corporation of America, with whom they are affiliated. The Elga and Siemens-Schuckert Companies are installing units of the vertical flow, original Cottrell type, although Siemens-Schuckert have modified this to the extent of using rectangular box sections with screen wire electrodes instead of tubes with chain electrodes. Litigation has the patent situation in a very cloudy state at present, but all three companies are installing units regardless of this uncertainty.

The dust content of the cleaned gas for use in stoves and boilers ranges from .05 to .15 grain per cu. ft., and for gas engines from .007 to .025 grain per cu. ft., depending on the ideas of different plant executives. Voltages used vary from 50,000 to 78,000 volts. The capacity of the Siemens-Schuckert installation for Krupp's new plant, to clean the gas from two 1000-ton blast furnaces, is calculated for 118,000 cu. ft. of gas per min.

Where gas is to be used for gas engines as well as stoves and boilers, normal practice is to install a

primary cleaner for the latter, and a secondary cleaner followed by hurdle cooling tower for the engine gas.

It may be of interest to note that the injection of water into a blast furnace at or near the tuyeres, which has been tried in Germany, is not generally received with favor. Neither is the proposition of withdrawing gases from the upper part of the furnaces.

German Ferro-Manganese

The blast furnace making ferro-manganese at Meiderich is noted in Europe for its large production.

Hearth diameter—11 ft. 6 in.

Coke rate—4070 lbs. per ton.

Production—280 to 300 tons per day of 78 per cent ferro-manganese.

Stove heat—1380 to 1425 deg. F.

Pressure—13 lbs. per sq. in.

Wind—Whatever above pressure will allow.

Furnace volume—15,885 cu. ft.

Ore—60 per cent Indian, containing 49 per cent manganese and 5 per cent iron; and 40 per cent Caucasian.

Slag contains about 12 per cent Mn and is used in blast furnaces for manganese addition.

Luxemburg Blast Furnaces

The largest furnaces in Luxemburg make about 350 tons per day. Hearth diameter is 16 ft. 5 in.

A furnace with 19-ft. 8-in. hearth is now being built at Dillingen and a production of 450 to 500 tons per day is expected from it. This furnace will have skip filling.

Some minette ores used have 26 to 28 per cent iron with enough lime to be self-fluxing; there are also silicious minettes which require lime additions or are mixed with limy minettes.

The question of crushing all ore to 3 in. and screening out the fines for sinter is under consideration at a number of these plants, but no installations are being built yet. They believe they can sinter with fine ore and flue dust alone. The latter contains 10 per cent carbon and 40 per cent iron. Flue dust production runs from 280 to 550 lbs. per ton of iron.

The Esch plant uses ore with 26 per cent Fe and enough lime in it for the whole burden. Production averages 270 tons daily per furnace. Coke consumption is 2,750 lbs.

Hot blast temperature is 1470 to 1650 deg. F. and furnaces will take all the heat they can get. Steel cast, brick-lined blowpipes are used. Blast pressure is about 15½ in. of mercury; furnaces are blown by pressure and not by wind volume.

Slag is from 2,640 to 2,860 lbs. per ton of iron.

At Völklingen, where fine ore is being screened out, sinter being made at present uses the following mixture in the charge:

	Per cent
Coke dust	10
Fine ore, minette	15-20
Flue dust	40
Mill scale	15
Sinter returns	15-20
Moisture	20

Raw Materials (Blast Furnaces)—The great advantage they have in European works lies in their raw materials, which constitute the burden of the blast

furnaces. At all the plants that we visited we saw good coke made in by-product coke ovens, fairly small and uniform in size and well screened, as they have a ready market for their domestic and fine coke.

Limestone is usually of good quality, but appeared to us more irregular and larger in size than we would use.

The ores (as shown in the detailed report on German blast furnaces) are very largely coarse and granular and sintering is done to a very large extent. In some cases they use up to 50 per cent of sintered material made out of the flue dust, purple ore, Swedish concentrates and fine ores. At the large plants they did not use much over 10 per cent sinter, nor did they separate their fine Swedish ores from the coarse, and used very little spathic ore. The average mixture was coarse enough so that they could produce up to 900 tons of iron per furnace per day on approximately 14 to 15 lbs. of wind pressure with somewhere around 55,000 to 57,000 cu. ft. of wind per min. This is their main advantage over us and their higher tonnages of 900 tons and over per day were not made over long periods of time; mostly for days or for weeks; in one or two cases for a month; while the average for the year would run between 800 to 825 tons of iron per furnace per day.

This was on furnaces at Hamborn having about 16 ft. 6 in. in hearth diameter, but a 24-ft. bosh diameter, which gave them a furnace capacity of about 24,000 cu. ft., which is comparable to the capacities of our blast furnaces having 18 ft. to 18 ft. 6 in. hearth diameters.

Therefore, even with their good ore conditions, they are not doing much better, if any, than many of our blast furnaces. We have a number of furnaces that are larger than this and are making from 800 to 900 tons per day. But the physical condition of the burden must always be considered and if we were to sinter a portion of our fine ores we would probably be able to obtain very much better results than at present and on lower pressures than now.

Sintering is being so generally adopted in Europe that we can learn a lesson from that.

Where they use the spathic, or minette, ores, their tonnages are small and of no particular interest to us, but in the Saar district they are beginning to separate the minette fines and sinter them, together with purple ores and flue dust.

Many of the sintering plants are of the Dwight-Lloyd design. They have also rotary agglomeration plants, but the former seems to be the favored system to install.

In the Luxemburg district the minette ore is so cheap that they cannot afford to mix anything with it as yet.

German Coke Oven Plants

The Hamborn Coke Works, August Thyssen Hutte, consists of four batteries, 65 ovens each, Koppers type, 14 in. wide and 9 ft. 10 in. high. Capacity is 750 tons of coke per 24 hours per battery.

Coking time is 16 to 17 hours.

Heating is done by blast furnace gas to save all rich gas for steel plant purposes and for sale to city.

Coals used are a mixture of 87 per cent high-volatile and 13 per cent low-volatile.

Coke is screened on $\frac{3}{4}$ -in. rotary grizzly screens, and domestic coke is rescreened from breeze. There is

a large outside demand for domestic coke and it is also used by some plants for producer gas. The breeze is used under boilers. Loss in screening is 7 to 8 per cent.

Coke is small and regular.

Standard value of by-product gas made is 440 Btu.

Self-sealing doors are on one battery, some showed considerable leakage of gas though the majority were tight. The apparatus is too delicate, repair costs are high, and they do not consider them satisfactory.

German Open-Hearth Department

The Hamborn open-hearth plant furnishes about 35 per cent of plant steel requirements, the other 65 per cent being basic bessemer steel.

Four 80-ton tilting basic furnaces yield about 100 tons each.

Fans are used for blowing the air in, and for drawing out the waste gases. Large checker chambers are used which take the heat out of the waste gas to about 600 deg. F., so the waste heat boilers formerly used are now blanked off.

Fuel is mixed by-product and blast-furnace gas, in proportion averaging one part by-product to two parts blast furnace. No special valves are used, the by-product gas being put into blast furnace gas main in quantity desired just before checker chambers so that the mixture is heated. They have tried straight blast furnace gas, but it is too slow.

Ingot mold life averages 100 heats.

Top pouring is used here, as throughout Germany on production steels. Bottom pouring has been tried, but sometimes gives trouble with sand getting in the ingot and is considered slow for big production.

Hot tops are not used, except for special steels.

At another works (Hoentrop) is the newest and finest open-hearth plant in Germany. The buildings are very high and large, of reinforced concrete and steel construction, as are also the bins for storage of ore, dolomite, etc.

There are four basic tilting furnaces, two of 120 tons, one of 189 tons, and one of 200 tons capacity. Tilting is done by one 100-hp. electric motor per furnace.

Revolving overhead charging cranes are used, though admittedly slower than floor cranes. Scrap is stored in bins beside the furnace floor, and cranes load it directly into the charging boxes, which sit on a platform opposite each furnace. The whole charge is made up on this platform, so there are no tracks in front of the furnaces. Hot metal is stored in a mixer at one end, and carried to the furnaces by the pit crane to be poured in the tapping hole.

Exceptionally heavy water-cooled port castings are used. Front walls, as well as back walls, are of magnesite brick and roofs of arched silica brick. They figure that flat suspended roofs are more expensive to install and repair. Three water-cooled pipes between water-cooled door frames serve to hold the front walls in place.

The total brick consumption is 17.6 lbs. per ton of steel.

Large checker chambers are used, about 23 ft. high, with $2\frac{1}{2}$ -in. checker brick and about 4-in. openings. The waste gas is about 850 deg. F., so no boilers are installed. Checkers are heated to 2000 to 2200 deg. F., measured by recording pyrometer with fire end projecting through top of the end wall.

Sixty to seventy-ton ladles are used in the pit, two ladles for small furnaces and three ladles for big furnaces each heat.

Charge averages 20 per cent pig iron and 80 per cent scrap, the cost of each is about the same. A typical charge on the big furnaces is as follows:

7,000 kg. cold pig.
30,000 kg. hot pig.
177,000 kg. scrap.
214,000 kg. total, or 214 tons.

Manganese content of the pig is 4 per cent, because the large scrap charge only runs about .4 per cent manganese and they want an average of 1.5 per cent in the total charge for good steel. The steel all goes into seamless tubes with .40 to .48 manganese, so they add some manganese ore in the bath before tapping.

Swedish ore (66 per cent Fe) is used, about 24 lbs. per ton of steel.

Burnt dolomite used averages 35 lbs. per ton of steel. It is burned in rotary and vertical kilns. Raw dolomite has been tried but they found the hot pig takes it out too fast.

Lime used averages 66 lbs. per ton of steel.

Fluorspar used averages 4.5 lbs. per ton of steel.

Capacity of the small furnaces is about 15 tons per hour, and of the large furnaces about 18. The small furnaces take about 8 hours for a heat and the large furnaces from 10 to 12 hours.

Fuel—By-product and blast-furnace gas are mixed for fuel, usual ratio being one part by-product to two parts blast furnace. The first helper regulates the amount of by-product gas according to the heat requirements of the furnace during various stages.

By-product gas gives about 450 Btu. per cu. ft.

Blast-furnace gas gives 106 to 112 Btu. per cu. ft.

Fuel consumption equivalent to about 3,968,000 Btu. per ton of steel.

One 4,000,000 cu. ft. gas holder is used for storing by-product gas and one of equal size for blast furnace gas.

Blast furnace gas should be cleaned to .025 grain of dust per cu. ft. or less.

Blast-furnace gas consumption is about 4,525,000 cu. ft. per 24 hours per furnace.

Fans are used for air only, giving pressure of about $\frac{3}{4}$ -in. water. Gas pressure at the checkers is $2\frac{3}{8}$ in. to $2\frac{3}{4}$ in. water.

Ladles are turned bottom up over a blast-furnace gas burner for drying.

Ingot molds are coated with a petroleum product called "Ertz Wax," a black material diluted with benzol and giving better results than tar. Ingots have a fairly good surface, they are all chipped and inspected before going to the mills.

All ingots at this plant are bottom poured because all ingots go to tube mill. Mill crop is about 25 per cent.

Ingot sizes vary from 5 in. to $27\frac{1}{4}$ in. in diameter, depending on size of tube to be made from them.

Mill Practice at Hamborn Plant

Rail steel is heated to 2200 deg. F. in the pits and blooms have a temperature of 2010 deg. F. The latter is measured with an optical pyrometer at the shears,

and theoretical losses added to check back to pit temperature. Rail ingots are each recorded through the mill by a pneumatic card system.

Rails up to 90 ft. $9\frac{1}{2}$ in. are rolled, the long length being used more and more. All rails are straightened on roller straighteners, which seem to give very satisfactory results and eliminate hand straightening, except for occasional twisted rails. Large section rails have about .5 carbon and .04 to .06 manganese.

Reheating furnaces throughout the mills use blast-furnace gas. Though the first cost of checkers is high, the operating costs are favorable because of high value of by-product gas for city use.

River Transportation—We saw loading and docking facilities at Duesseldorf and Duisburg, which are very fine. River transportation up and down the Rhine is quite extensive.

General

The outstanding features noticeable during these visits were the strong tendency to Americanize the plants, especially the blast furnace plants by following our blast furnace lines and in some cases our methods of construction.

In the coke-oven plants we saw a number of modern American type ovens, all built with the idea of utilizing all of the rich gas in the steel mills or for public service, and heating the ovens with either blast-furnace or producer gas.

There was not much new in the by-product coke oven end.

Modern Furnaces for Normalizing Steels

(Continued from page 1573)

in end of the soaking zone is being maintained. As previously mentioned thermocouples in this zone are 20 ft. apart and show a proportionate drop in furnace and sheet temperature of about 100-200 deg. F. between couples. As a result the sheets emerge from the furnace at a temperature around 900-1000 deg. F. The sheets are then carefully pulled to one side from the runout table and the waster sheet is piled ready to be used again when cool enough to be handled.

An examination of the sheets at this point show an excellent surface considering their exposure. There is no scale on the sheet which indicates the presence of a good reducing atmosphere throughout the entire length of the furnace. This feature reflects its advantage as very little acid and pickling time are necessary for the preparation of the sheet for its finishing processing before shipment.

The metallurgical control over this furnace brings out the physical properties in a very unique way, the control being made by microscopic examination and tensile strength tests. In this respect these two factors are so correlated at this mill, that their relation is fairly proportional assuming that all variable factors such as chemical analysis, method of rolling and conditions of normalizing are the same. The yield point of the "yield" as they designate it, is around 75-85 per cent of the ultimate or in other words the yield point is approximately this percentage of the ultimate tensile strength.

A strictly up-to-date testing and metallographic laboratory permits a close watch over the action of this normalizer at all time.

Steel Requirements of Aircraft Industry*

Present Development in the Art of Flying Has Brought New Problems to the Steel Industry—Value of Steels Required to be Considered Instead of Tonnage

By H. J. FRENCH†

PART II

MANY metal aircraft parts are intricate in design and up to the present time have been built up from tubing, sheet, wire and bar stock (see Fig. 3). Their construction, therefore, involves much hand work and necessitates one or more of the operations of cutting or other machining, hot or cold forming, punching and joining by riveting, welding, soldering or brazing. The steels used in the manufacture of such parts as fittings must, therefore, be readily workable in various ways, not only from the standpoint of reduced costs but also because it becomes increasingly difficult to insure reliability in service as the metals used in construction become more difficult to fabricate.

Simpler fabrication methods such as forging, extrusion, etc., will probably be applied more generally when there is quantity production over which to distribute the cost of dies. However, built-up structures

have been and are at present very widely used and ease of fabrication is sometimes one of the principal factors governing the selection of materials.

The complexity of aircraft construction is illustrated in Fig. 4, which shows an experimental metal wing structure made of duralumin tubing and steel wire. The older wooden wing construction is shown on the shelf at the left side of the illustration.

Special Performance Requirements

A few illustrations will show the severity of the detailed technical requirements often encountered in aircraft parts. For example, in highly stressed parts the smoothness of surface may be of paramount importance. Fig. 5 shows part of an aluminum alloy propeller which failed in service. The break is a typical fatigue fracture and was the direct result of the identification marks which were stamped rather deeply in the blades. The start of the crack which produced failure can be seen at the base of the impression in Fig. 6.

*Abstract of paper read before the American Iron and Steel Institute, New York, October 26, 1928.

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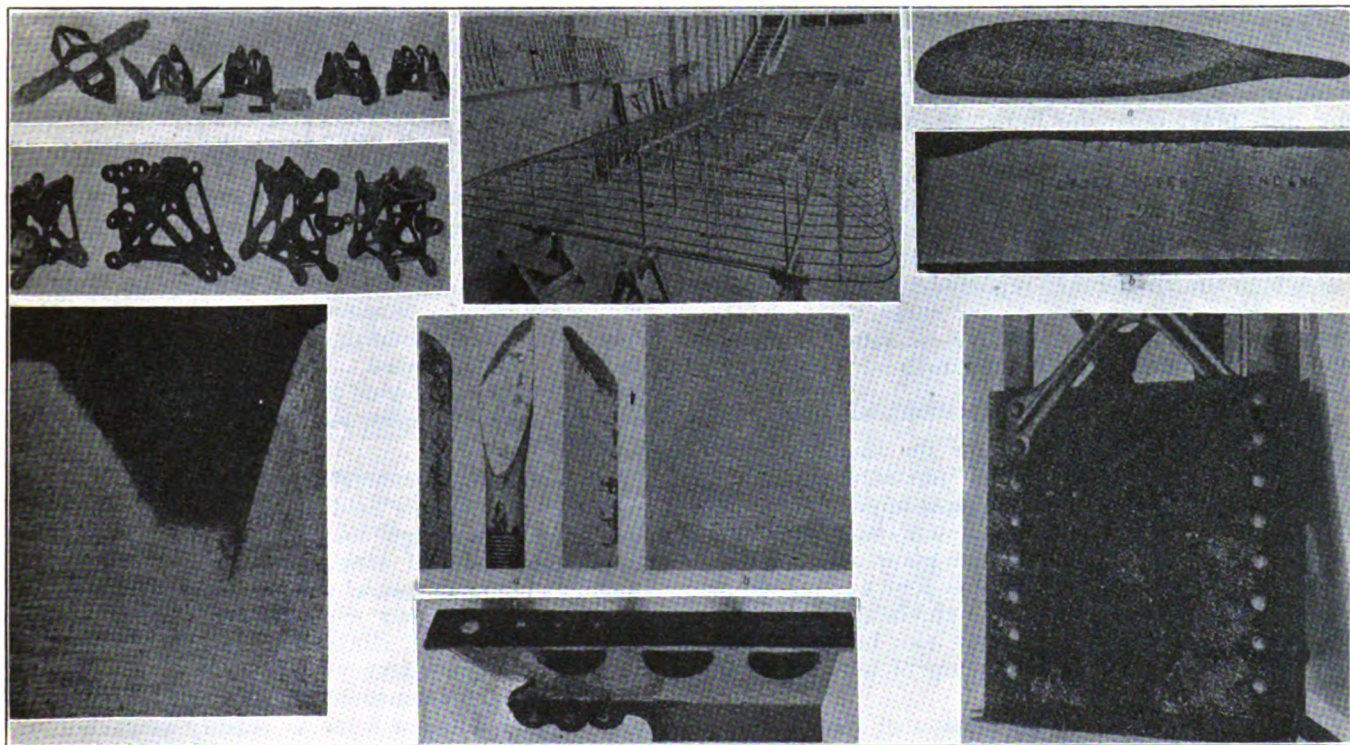


FIG. 3 (upper left)—Typical steel fittings used in aircraft construction. The top row of photographs illustrates the progressive stages of manufacture of a wing hinge fitting for a flying boat. Courtesy of Naval Aircraft Factory, Philadelphia, Pa. FIG. 4 (upper center)—Duralumin wing structure (experimental). Note the wooden wing structure on the shelf at the left. Courtesy of Wright Field, Dayton, Ohio. FIG. 5 (upper right)—Aluminum alloy propeller which failed by fatigue, X1. a—Appearance of fracture. b—Face showing how the break followed the stamped identification marks. FIG. 6 (lower left)—Impression showing start of crack at bottom. FIG. 7 (center)—Three streamline wires which failed by fatigue. a—The wires. b—Unetched section showing numerous inclusions in the steel. These were probably not responsible for failure but are considered to be deleterious and may be taken to indicate steel of poor quality, X100. FIG. 8 (lower center)—Corroded duralumin airplane fitting. FIG. 9 (lower right)—Part of a duralumin girder of the type used for airships, after three years' exposure to the atmosphere. The carbon steel end plates are badly rusted while the duralumin channels and lattices show no appreciable surface attack. Courtesy of H. S. Rawdon, Bureau of Standards.

Resistance to fatigue is important in many steel parts. An illustration is furnished in Fig. 7a which shows three stream line wires which failed in service. The cause in these cases was probably related to the detail of design, but examination revealed steel filled with non-metallic inclusions (Fig. 7b) and it would be difficult to prove that these did not play a part in the failures. Such circumstances help to increase the severity of specifications for aircraft steels.

Fig. 8 shows the corrosion of a part of the fuselage structure located near the lower rear wing hinge on a seaplane. This structure, which carries the aileron pulleys, is more or less in the open and may be splashed by spray in take off and landings. The corroded portion of the specimen was quite brittle as a result of the intercrystalline corrosive attack which had taken place and the corrosion was concentrated near the rivets, but the rivets themselves were not seriously affected.

The effect of corrosion is especially notable when the corrosion is combined with repeated stress. Under corrosion in salt water, and to a slightly smaller degree in fresh water, the endurance limit is greatly reduced. McAdam* cites the case of a heat-treated nickel-silicon steel, with a proportional limit of 155,000 lbs. per sq. in., a tensile strength of 254,000 lbs. per sq. in., an elongation of 8.5 per cent in 2 in. and a reduction of area of 46.5 per cent, which had an endurance limit in air of 108,000 lbs. per sq. in. Under corrosion, its endurance limit dropped to 12,000 lbs. per sq. in., or below that of American ingot iron, (15,000 lbs. per sq. in. in air).

The corrosion-fatigue limit of ordinary stainless steel is about 25,000 lbs. per sq. in., and that of some of the austenitic stainless steels may reach 30,000 lbs. per sq. in. When corrosion and repeated stress both come into play, only the high chromium steels can be considered to be in competition with duralumin (with its corrosion-fatigue limit at about 8,000 lbs. per sq. in.) on a strength-weight fatigue basis. Fig. 9 illustrates why duralumin and stainless steels (not carbon steels) are the competing materials in the airships which the British are reported to be building in parallel. Performance records for these ships should throw much light on the relative efficiency of duralumin and stainless steel construction.

Typical Practice and Applications of Steel

Power Plant—The character of the steels required for aircraft construction may be illustrated by considering present practice and typical applications. In discussing this subject briefly, it will be convenient to deal separately with the power plant and the aircraft construction. This division is logical, both from the standpoint of the industry, which at present is rather definitely divided into these two branches, and from the standpoint of the character of the service to be performed.

Probably the largest consumption of steels in the aircraft industry is applied in power plant construction, but the present air-cooled aircraft engines are not entirely constructed of steels, as will be evident from Table B, which gives the weight analysis of a popular air-cooled engine.

In the case of the aircraft power plant the problems of construction differ in degree, but not radically

*D. J. McAdam, "Fatigue and Corrosion Fatigue of Metals," Report, International Congress for Testing Materials, September 1927, p. 305.

TABLE B—Percentages of Various Materials Used in the Construction of the "Wasp" Aircraft Engine.*

Material	Weight	
	Pounds	Per cent
Brass	4.06	.62
Bronze	19.00	2.94
Aluminum	215.71	33.40
Duralumin	55.49	8.60
Copper	.56	.08
Rubber, vellum, etc.	1.05	.16
Steel (by difference)	350.00	54.20

*Courtesy of Pratt & Whitney Aircraft Company, Hartford, Conn.

in nature, from those of the automotive power plant. Practice varies for different engines, but as a general rule little carbon steel is used, except in the cylinders and for parts of low strength which may require deep forming or welding in their manufacture. Parts requiring high strength, such as crankshafts, connecting rods (Fig. 10), gears, shafts and many nuts and bolts, are quite generally made from structural alloy steels similar to those so widely used in the automotive industry. These may be the nickel, nickel-chromium or chromium-vanadium steels and their strength and hardness in the condition used is sometimes limited, as in crankshafts, by the necessity of machining subsequent to heat treatment.

The steels which have been most widely used in important parts of the power plant are included in Table C with notes concerning typical applications. The compositions given are representative but not exact and it should be noted that manufacturers have frequently used different compositions from time to time for the same parts in one make and size of engine.

Cylinders and cylinder liners—The cylinders or cylinder liners have most often been made of carbon steels. Those of the Gnome engines, manufactured in the United States about 1916, were made of about 0.5 per cent carbon steel forgings normalized after forging. Liberty engine cylinders, produced during the early part of the World War, were formed hot from seamless steel tubing or pierced and drawn from forged blanks of steel containing about 0.4 per cent carbon and then heat treated. Steels containing about 0.45 per cent carbon are used in the cylinder barrels of modern air-cooled engines, such as the Whirlwind, Wasp and Hornet.

However, carbon steels are not necessarily destined to hold sway in this field. One manufacturer is using nickel steel castings, another is using welded chromium-molybdenum steel, and there is a possibility that the nitrided special steels will find application in cylinder construction. Steel containing various combinations of nickel, chromium and molybdenum with aluminum acquire a very hard surface when heated in ammonia at temperatures in the neighborhood of 930 deg. F. and will not seize as readily as carbon steels when in contact with the metals ordinarily encountered in the construction of internal combustion engines.

Crankshafts, connecting rods and other high strength parts—The nickel-chromium steels containing about 1.25 to 2.0 per cent of nickel and 0.6 to 1.10 per cent of chromium have probably been the most popular of the alloy structural steels used and in forging grades contain about 0.35 to 0.45 per cent carbon. However, there is not complete standardization with respect to the steels now used for crankshafts, connecting rods.

TABLE C—Typical Steels Used in Aircraft Construction.

Steel	Chemical composition—per cent*									Remarks
	C	Mn	Si	Ni	Cr	V	Mo	W	Co	
For low stress engine parts										
Mild carbon	0.15	0.65	....	....	....	....	....	....	....	Carburized—for camshafts.
Mild carbon	0.25	0.65	....	....	....	....	....	....	....	
For forgings, including cylinders and cylinder liners.										
Medium carbon	0.40	0.65	....	....	....	....	....	....	....	
Medium carbon	0.50	0.65	....	....	....	....	....	....	....	
Structural alloy steels for crankshafts, connecting rods and other high stress engine parts.										
3½% nickel†	0.40	0.65	....	3.5	....	....	....	....	....	Connecting rods and bolts. Crankshafts.
Nickel-chromium	0.40	0.65	....	1.25	0.6	....	....	....	....	
Nickel-chromium‡	0.40	0.65	....	1.75	1.0	....	....	....	....	Most popular composition for crankshafts.
Nickel-chromium	0.40	0.65	....	1.0	1.0	....	....	....	....	
Nickel-chromium	0.35	0.65	....	3.0	0.75	....	....	....	....	
Chromium-vanadium ..	0.35	0.80	....	....	0.9	0.18	....	....	....	
Nickel-chromium	0.15	0.65	....	1.25	0.6	....	....	....	....	Carburized—for valve tappets.
Gears and pins.										
Chromium-vanadium ..	0.50	0.70	....	....	0.9	0.18	....	....	....	} Drive and reduction gears. Carburized }
5% nickel	<0.17	0.35	....	5.0	....	....	....	....	....	
Nickel-chromium	<0.12	0.45	....	3.5	1.5	....	....	....	....	Gears and case hardened pins. Oil hardened gears.
Nickel-chromium	0.35	0.45	....	3.5	1.5	....	....	....	....	
Sheets										
Chromium-vanadium ..	0.22	0.80	....	....	0.9	0.18	....	....	....	} Being replaced by chromium-molybdenum. Body steels—rivetted and welded construction.
Chromium-molybdenum	0.30	0.50	....	....	0.9	....	0.20	....	....	
Mild carbon	0.25	0.65	....	....	....	....	....	....	....	
Very low carbon	0.10	0.65	....	....	....	....	....	....	....	
Tubes										
Mild carbon	0.15	0.65	....	....	....	....	....	....	....	} Body steels—rivetted and welded construction. Large amount supplied for body work.
Mild carbon	0.25	0.65	....	....	....	....	....	....	....	
Chromium-molybdenum	0.30	0.50	....	....	0.9	....	0.20	....	....	
Wire										
Medium carbon	0.45	0.65	....	....	....	....	....	....	....	Streamline wire.
Carbon-manganese	0.45	1.0	....	....	....	....	....	....	....	Beading and general utility.
High carbon	0.95	0.30	....	....	....	....	....	....	....	Music wire for springs.
Chromium-vanadium ..	0.50	0.70	....	....	0.9	0.18	....	....	....	Valve springs.
Valves										
Chromium-silicon	0.45	....	2.5	....	8.0	....	....	....	....	Inlet and exhaust valves.
Chromium-tungsten ..	0.60	....	....	....	0.75	....	....	1.75	....	Inlet valves.
Chromium-tungsten ..	0.60	....	....	....	3.5	....	....	13.5	....	Inlet and exhaust valves.
Chromium-tungsten ..	0.60	....	....	....	3.5	....	....	16.5	....	Inlet and exhaust valves.
Cobalt-chromium	1.3	....	....	....	13.0	....	0.75	....	3.0	Inlet and exhaust valves.
Miscellaneous parts.										
High chromium	<0.30	....	....	13.0	....	....	....	....	....	} Pump shafts, experimental. Largely experimental where corrosion resistance is desired.
High-chromium	<0.12	....	....	13.0	....	....	....	....	....	
High nickel-chromium ..	<0.12	....	8.0	20.0	....	....	....	....	....	Tail skid shoe. For non-magnetic properties.
14% manganese	2.0	14.0	....	....	....	....	....	....	....	
High nickel-chromium ..	.35	....	2.5	25	17	....	....	....	....	

*These are typical compositions but not all that have been used. Modifications are encountered depending upon personal preferences of individual manufacturers.

†Same steel with 0.30 per cent C used in bolts on plane construction.

‡Some makers use 0.60 per cent Cr instead of about 1 per cent.

gears and other engine parts requiring high strength. So long as the required mechanical properties can be secured by simple heat treatment, the chemical composition selected is of much less importance than the quality of the steel and the ease of forging and machining. Flaky fractures, hair line seams or cracks, inclusions and lack of uniformity are viewed with suspicion and have probably caused more rejections than lack of strict adherence to simple chemical requirements, provided this did not alter materially the

working properties and strength of the heat-treated parts.

The constant search for better materials of construction in the aircraft industry is illustrated by the recent application to wrist pins, pump shafts, gears, and ball and push rod ends of nitrided chromium-molybdenum-aluminum steels. A typical composition is 0.40 per cent carbon, 1.5 per cent chromium, 0.20 per cent molybdenum and 1.10 per cent aluminum.

Valves—Exhaust valves in airplane engines are an ex-

ample of severe performance requirements. Operating conditions vary with the engine but temperatures up to 1600 deg. F. are encountered. Hollow stems filled with oil, mercury or salt have been used to reduce the operating temperatures and this device, as well as other features of design, has been helpful in prolonging the life of valves. However, there is still need for improved valve steels which will better resist erosion from the hot exhaust gases, have a low rate of oxidation, maintain their hardness at exceedingly high temperatures and permit easy fabrication and the production of hard strong stems.

Many steels have been used for valves but those most generally applied at present are the chromium-silicon, the cobalt-chromium and the high-tungsten-

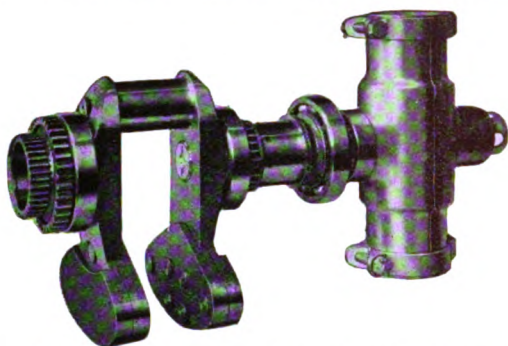


FIG. 10—Crankshaft assembly of the air-cooled Hornet motor. Courtesy of Pratt & Whitney Aircraft Company, Hartford, Conn.

chromium steels whose compositions are shown in Table C.

A promising development in valve steels is the nitriding of chromium-silicon-aluminum steel, containing about 8 per cent chromium, 2.5 per cent silicon, 1 per cent aluminum and 0.45 per cent carbon. Another steel now used in the exhaust valves of a well-known air-cooled engine is a chromium-nickel-silicon steel whose composition is based on stainless steel. This steel is of metallurgical interest, since it does not react in the same way as ordinary steels to the usual processes of heat treatment.

Propellers—The wooden propeller has now been replaced quite largely by the metal propeller, which does not tend to chip and split when operating in snow and sleet. However, metal propellers are subject to fatigue and failures from this cause and sometimes encountered after relatively short service. (Fig. 5).

The majority of metal propellers are made of a forged aluminum alloy containing about 4.5 per cent copper, 0.75 per cent manganese, 0.75 per cent silicon, balance aluminum. Steel propellers have been produced and according to some writers*† are entirely satisfactory, give an increase in the rate of climb and the top speed of the plane and are recommended for fast planes.

Aircraft Construction

Fuselage and control surface construction is generally either of steel or duralumin, while the wing structure is most often made of wood or duralumin with steel fittings and wires. Steel is used for spars, especially in large units, but the wing ribs are usually

*W. P. MacCracken, Jr., "Commercial Aeronautics and Steel," Iron Age, Vol. 119, No. 14, April 7, 1927, p. 987.

†A. Klemin and G. F. Titterton, "Materials of Aircraft Construction," Heat Treating and Forging, May, 1928, p. 518.

of duralumin or wood. The landing gear and engine mounts are generally made of steel but aluminum alloy construction is also found.

Steel construction is generally based on seamless steel tubing with welded joints. Duralumin construction requires riveted joints in formed sheets or tubes, as it is impracticable to secure satisfactory welded joints. Hence, there is an enormous amount of hand-work in the usual duralumin construction. However, it has an advantage over the steel of lower weight and higher stiffness for equal strength, but it is more expensive under the present conditions of small production where die costs cannot be distributed over a large number of units. There is some question whether welded steel joints have the necessary degree of reliability, but recent improvements in electric welding practice will probably do much to eliminate such questions. Steel has the advantage over the aluminum alloys in bearing surfaces, where high strength and relatively high hardness are desired, and in the cost of fabrication.

A single-seat fighting machine which, with the exception of the landing gear, is constructed almost entirely of duralumin, with a 200-hp. motor, covering and equipment, but without gasoline and oil, weighs only 1027 lbs.

As a general rule, so-called duralumin construction includes the use of appreciable percentages by weight of steel. A typical example is the Martin Model T 4 M-1. While largely of duralumin construction, Table D shows that the steel fittings and other steel parts constitute about 31 per cent of the dead weight without engine. This is about the same proportion of steel found in a well-known commercial plane, the construction of which may be characterized as steel and wood. The steel used is roughly 25 per cent of the empty weight of about 3,000 lbs.

TABLE D—Summary of Weight of Steel Parts of Martin Model T4M-1 Airplane.*

Item	Total weight of group	Weight of steel parts	Per cent weight of steel
Wing group	1094	291	26.6
Tail group	131	29	22.2
Fuselage	717	172	24.0
Landing gear, arresting gear, etc...	441	185	42.0
Power plant, total	1154	...	...
Power plant less engine	404	218	54.0
Fixed equipment	353	90	26.0
Dead load, total	3890	...	...
Dead load, less engine	3140	985	31.4

*Courtesy of Glenn L. Martin Company, Cleveland, Ohio.

The welded steel tube construction is widely used in fuselage and control surfaces. While less expensive than the riveted duralumin construction, careful welding technique is required to avoid cracked joints and distortion of complicated structures, such as engine nacelles.

Only a few steels have been generally adopted for stressed members of aircraft. These comprise mild carbon steels in the form of sheets, bars and tubing, medium carbon steel for forgings and tubing, high carbon steels for springs and tension wires, chromium-molybdenum steel sheets, bars, and tubing. The chromium-vanadium steel sheets formerly used have been replaced largely by chromium-molybdenum steel sheets. Typical compositions are shown in Table C.

Sheets and tubing—Mild carbon steel sheets, bars and tubing are used in the manufacture of fittings but have been supplanted by chromium-molybdenum steel sheets and seamless tubes where high strength is desired.

Tubing is also used in the landing gear. Steels containing 3.50 per cent nickel or about 1.25 per cent nickel and 0.6 per cent chromium have been used, but are being replaced to a considerable extent by the chromium-molybdenum steel. The tubes used in axles are generally quenched and tempered for tensile strengths in the neighborhood of 175,000 to 200,000 lbs. per sq. in. and offer problems in heat treatment.

Wire—High carbon steel wire in round, square and streamline sections is used for tension members, such as tie rods, drift wires and stays. The streamline form is employed for exposed parts and the others for internal construction. Stranded steel cable is found in the control wires which are subject to bending and must be flexible. Stiff cable is used for bracing.

Miscellaneous—Ordinary carbon steel castings have not yet found application in aircraft construction, but have been tried experimentally in landing gears. The 14 per cent manganese steel is used in the tail skid shoe, where a high degree of toughness, resistance to shock and wear are important.

Stainless steels have not yet been used extensively for aircraft construction but offer promising possibilities. For example, water tight pontoon construction is difficult to obtain with duralumin, which tends to corrode at welded points unless heat treated subse-

quent to fabrication. As heat treatment is generally impracticable, riveted and caulked joints are now used. Satisfactory joints have been obtained in experiments with soldered stainless steels, and this practice is simpler and cheaper than that required with the present aluminum alloys.

A limited application of stainless steels is found in engine exhaust pipes and exhaust line valves.

The tonnage requirements for steels for aircraft construction will probably remain a small part of the total steel production, since one object always in view is to keep down the dead weight of flying equipment. However, since special steels are needed, the market value of the demand is high. Expansion in manufacturing facilities will create a demand for machine tool equipment and the customary tool and die steels and there will likewise be needed a considerable amount of structural shapes and sheets for airport and airway construction. There should, therefore, be some measure of attractiveness in the business which will eventually come to the steel industry from the aircraft industry.

Steels will probably continue as one of the principal metals of construction, especially for large flying units, unless technical progress in the steel industry is overshadowed by developments in non-ferrous metallurgy. Steels at least equal to those used for important parts of automotive equipment are required, especially for engine parts, and there is evidence that much of the demand will be for materials of super-quality, that is, of an exceedingly high order of purity, cleanliness and uniformity.

Present Status of Structural Steel Welding*

Pertinent Questions Regarding Welding and Bearing on the Use of Welding in Fabricated Steel Structures Are Here Clearly Answered — Features of Practical Interest Covered

By F. T. LLEWELLYN†

PART II

CAN methods of making welds by different processes be standardized? The answer to this question is "Yes"! Specifications covering the making of welds by the d.c. metalarc process, and by the oxy-acetylene gas process, have already been prepared by the Structural Steel Welding Committee, and are being distributed in printed form (sections C and D) to the fabricating shops participating in the preparation of specimens. The committee prefers to postpone any general distribution of these specifications until the conclusion of its major program, when it should be evident whether modification of the requirements is desirable.

In addition, a number of representative shops are now engaged in structural welding on a commercial basis, and many of these have prepared for their own use suitable specifications covering methods of making welds. There is reason to expect that details will also be standardized. Already we are using $\frac{3}{8}$ -in. fillets as standard in much the same way as $\frac{3}{4}$ -in. rivets have been standard in older methods of fabrication.

*Abstract of paper before the American Iron & Steel Institute, New York, October 26, 1928.

†President, American Welding Society, New York City.

An authoritative specification covering method will doubtless be available to the industry within the next year or two. The demand is apparent.

Can Values be Fixed on Some Unit Basis for the Strength of the More Usual Types of Welded Joints?

To this question the writer would give a qualified answer. For quiescent static loads, "Yes"! For dynamic loads, "Probably Yes"! Welded joints subjected to considerable shock require further investigation. Some of the writer's associates in the welding fraternity may consider the qualification as regards dynamic loads to be unduly conservative; but there is evidence that forms of welded joint, which have a known resistance under static load, cannot when merely increased by the usual impact ratio be considered to have the same resistance under shock. It does not follow that welded joints are unsuited to resist shock. Many structures are now in use where they perform this function very efficiently. It is a fact, however, that our knowledge as to their precise behavior under shock is limited, and the need for further study along this line is urgent.

The situation with regard to welded joints subjected to quiescent or static load is entirely different. We have hundreds of tests under this kind of loading, whose results agree with as much uniformity as do those on unfabricated steel, and with more uniformity than many of the tests that have been made on steel fabricated by other methods.

In discussing the properties of welds it is necessary to distinguish between the strength of the neat deposited metal and the strength of the joint as a whole. Dustin reports a series of tests, made at Brussels, on deposited metal without reference to the members to be joined, using three different brands of coated wire. He does not state whether a.c. or d.c. was employed. The three brands of wire are here designated respectively by the symbols B, T, and N. All of them were of mild steel containing 0.10 to 0.14 per cent carbon.

Wire B was very high grade, but costly. It was electroplated with 1.25 per cent of nickel and carried a thick coating confined by a braided asbestos covering. It is not representative of grades commonly used in America for structural work, but its results are interesting as showing the high physical properties that can be secured by the use of a suitable wire.

Wire T carried no nickel and had no enveloping fabric. Except for its heavy coating, it seems to parallel the better grades of wire that are used in this country for structural work, its carbon being intermediate between our classes E 1 A and E 1 B.

Wire N was a cheap grade, corresponding apparently to material used here for minor repair work, except that it had a thin coating.

Table B shows the ultimate tensile strength of 105 specimens, of three sizes, consisting of neat weld metal deposited by wires B, T, and N. We may approximate their averages at 70 kips for metal B, 56 kips for metal T, and 50 kips for metal N. The uniformity of the results for each metal is very satisfactory. Not less so is the fact that even those specimens that showed small visual defects developed values well above the yield point of mild rolled steel.

TABLE B—Tests on 105 Specimens of Neat Metal (Dustin).

Ultimate tensile strength in kips (1000 lbs.) per square inch.								
Metal B (Diameter, in.)			Metal T (Diameter, in.)			Metal N (Diameter, in.)		
0.39	0.79	1.18	0.39	0.79	1.18	0.39	0.79	1.18
69.8	78.4	71.1	54.1	59.9	58.5	43.4A	42.7A	47.8
69.8	76.9	69.8	42.8A	59.9	60.6	40.6A	37.8A	46.4
74.0	67.6	71.1	39.9A	62.6	60.6	44.1A	36.4A	46.4
72.5	75.5	73.5	44.2A	62.6	64.7	42.7A	46.5	47.8
74.0	66.9	63.8	57.0	57.7	48.3	49.8	49.8	41.3
68.3	71.1	59.1	59.2	60.5	51.2	54.0	54.0	41.2
....	73.4	61.2	43.5A	57.0	49.8	44.1A	52.0	40.6
....	74.0	68.2	58.4	57.0	....	49.1	49.8	....
....	71.1	59.8	57.6	50.5	....	41.3A	49.8	....
....	75.5	65.5	64.7	60.5	....	54.0	49.8	....
....	62.6	64.0	64.7	53.4	....	59.8	56.3	....
....	62.6	....	59.1	62.6	....	57.0	54.0	....
....	66.9	....	55.5	58.4	....	....	54.0	....
....	76.9	....	....	57.0	....	....	....	....
....	76.9	....	....	56.1	....	....	....	....
....	68.3	....	....	57.0	....	....	....	....
....	75.5	....	....	57.0	....	....	....	....
....	....	....	....	57.0	....	....	....	....
....	....	....	....	56.6	....	....	....	....
Gross Averages								
71.3	71.7	66.0	54.0	59.0	56.2	48.4	48.4	44.4
Net averages disregarding 13 specimens (A) with visual def'ts								
....	....	....	59.0	59.0	56.2	54.0	51.3	44.4

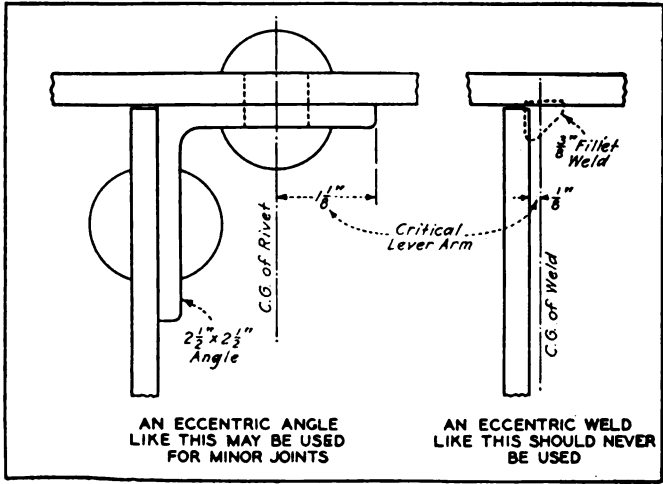
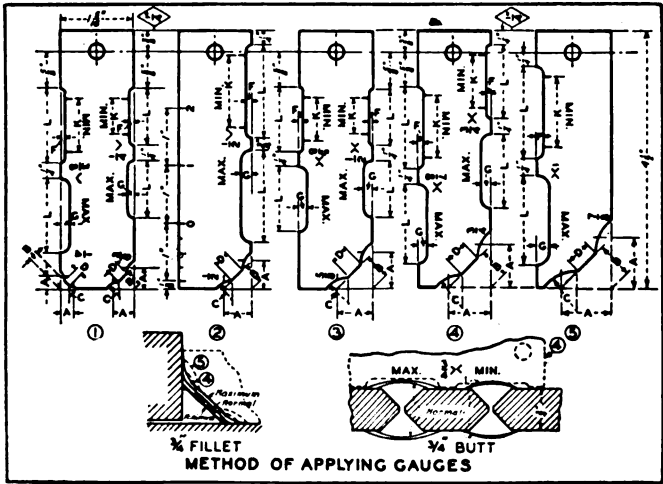


FIG. 2 (upper)—Gauges for fillet and butt-welds.
FIG. 3 (lower)—Comparison of eccentric joints.

Table C shows the results of slow tension tests on 21 small specimens. The values for ultimate tension agree fairly well with those of Table B. The yield points average approximately 51 kips for metal B, 42 kips for metal T, and 38 kips for metal N. The elongation values definitely reflect the respective qualities of the wires used.

Other tests on metals B and T indicated moduli of elasticity under tension of 29,000 kips, and under shear of 21,000 kips. These are substantially the values for mild rolled steel. They also indicated average ultimate strengths under shear of 48 kips for metal B and 41 kips for metal T, with corresponding yield points of 27 and 22 kips. Dustin's tests for impact and fatigue were not very regular or conclusive. He warns against the use of any but high grades of wire in structures where much shock is to be withstood or where there will be alternating repeated stress of considerable amount. The Lloyds Rules require a weld subject to fatigue to resist 12.8 kips per sq. in. for 5,000,000 cycles. This value is about half the yield point of sound weld metal deposited by good grades of wire.

TABLE C
Slow Tests on 21 Specimens of Neat Weld Metal (Dustin).

All specimens 0.39 inch diameter			
Deposited metal	(Kips (1000 lbs.) per sq. in.) Ult. tens. strength	Yield point	elongation in 3.9 in.
B	72.5	54.5	12.0
	72.1	50.0	22.7
	71.3	55.0	18.9
	71.1	50.0	24.0
	69.8	49.8	10.0A
	62.6	51.2	7.6A
Averages	69.8	51.3	17.2
T	59.8	46.5	25.0
	58.0	44.1	18.7
	57.0	41.7	14.2
	56.1	39.4	18.5
	56.0	43.9	B
	52.7	42.0	7.6A
Averages	56.7	42.4	16.8
N	55.2	43.4	19.3
	56.0	43.0	20.0
	54.3	41.5	B
	59.7	28.4	B
	51.2	31.3	4.1C
	42.7	34.1	3.0C
	55.5	39.8	16.0D
	54.0	39.8	12.0D
	55.5	38.4	12.0D
Averages	53.8	38.4	12.3

A—No serious defect visible.

B—Broke beyond gage-marks.

C—Serious visible defects.

D—Broke between shoulders, but beyond range of extensometer.

The use of gages is recommended in order that the welds as actually made shall conform to theoretical dimensions within reasonable tolerances. In Fig. 2 is shown a set of five convenient gages, each only $4\frac{1}{2}$ in.

long, which can be applied to $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, and 1 in. butt welds, and $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$ and $\frac{7}{8}$ in. fillet welds. The method of application is shown at the bottom of the figure. The limiting dimensions are tabulated in Table D. These gauges have been used commercially by the Newport News Shipbuilding & Drydock Company for some years and are now being employed in the major program of the Structural Steel Welding Committee. A system for checking the number and location of welds is essential.

TABLE D—Dimensions for Weld Gauges (Inches).
Fillet Welds

Nominal size (A)	Throat (B)	Normal	Radius (C)	Dimension (D)
$\frac{1}{4}$	.177	.221	$\frac{3}{16}$	$\frac{1}{8}$
$\frac{3}{8}$	.265	.309	$\frac{1}{4}$	$\frac{3}{16}$
$\frac{1}{2}$	.354	.398	$\frac{3}{8}$	$\frac{1}{4}$
$\frac{5}{8}$	.442	.486	$\frac{1}{2}$	$\frac{5}{16}$
$\frac{3}{4}$	.530	.574	$\frac{5}{8}$	$\frac{3}{8}$
$\frac{7}{8}$	.619	.663	$\frac{3}{4}$	$\frac{7}{16}$

Note—Dimension (D) is symmetrical about 45 deg. axis from corner of gage. At no point shall weld fall below triangle of its nominal size, nor exceed triangle of nominal size $\frac{1}{8}$ in. greater.

Butt Welds (Angle between bevels 75 to 90 deg.)

Nominal size (E) plate thickness	Reinforcement for single "V"			Reinforcement for double "V" each side			Width (K)		Max. (L) are welds only
	Min. (F)	Max. (G)	Normal	Min. (F)	Max. (G)	Normal	Min. (K)		
$\frac{1}{4}$	.063	.125	3/32	....	....	....	5/8	1	
$\frac{3}{8}$	.063	.156	3/32	....	....	....	15/16	1 1/16	
$\frac{1}{2}$	.094	.187	$\frac{1}{8}$	....	....	....	1 1/4	1 5/8	
$\frac{3}{4}$	....	....	....	.050	.150	3/32	5/8	1	
$\frac{5}{8}$	....	....	....	.063	.162	3/32	25/32	1 1/8	
$\frac{3}{4}$	....	....	....	.075	.175	1/8	15/16	1 5/16	
$\frac{7}{8}$	....	....	....	.088	.187	5/32	1 3/32	1 7/16	
1	....	....	....	.100	.200	5/32	1 1/4	1 5/8	

TABLE E—Some Welded Buildings Erected in 1927-1928.

Location	Owner	Description	Size, ft. W'dth L'gth	No. of stories	Approx. steel tonnage	Class
Derry, Pa.	Westinghouse E. & M. Co.	Light manufacturing building	164 460	1	350	1
W. Philadelphia, Pa. ..	General Electric Co.	Manufacturing building with crane runways	138 552	2	1000	2
Pittsfield, Mass.	General Electric Co.	Manufacturing building	39 280	2	250	1
			21 280	1	....	
Chicago, Ill.	Mississippi Valley S. S. Co.	Steel warehouse with crane runways	135 340	1	400	2
			Clear 60	1	300	2
Emeryville, Cal.	Associated Oil Co.	Automotive shop	72 136	6	550	5
			56 56	12	....	5
Hot Springs, Va.	Homestead Hotel	Addition to hotel	72 79	6	350	5
			74 140	4	200	1
Atlantic City, N. J. ...	Chalfonte-Haddon Hall	Power house	28 32	2	....	
N. Tonawanda, N. Y. ...	Tonawanda Power Co.	Office building	150 220	18	....	5
New Haven, Conn. ...	Yale University	Supports for book stacks		150 ft.		

TABLE F—Some Welded Bridges Erected in 1927-1928.

Location	Owner	Description	Spans Num-ber L'gth (ft.)	Total length (ft.)	Approx. steel tonnage	Class
Leavenworth, Kan. ...	C. and G. W. R. R. Co.	Reinforcement of railroad bridge	3 ...	1100	100	3
Havre de Grace, Md. ...	State of Maryland	Double decking of highway bridge	... 250	3300	1500	3
Chicopee Falls, Mass. ...	Boston & Maine R. R.	Single track railroad bridge	1 135	170	100	2
			Skew 85	170	50	3
Bound Brook, N. J. ...	Public Service Co.	Renewal of highway bridge	2 ...	....	250	3
Memphis, Tenn.	Harahan Bridge	Widening of roadway	... ..	1800	150	Spec.
New York, N. Y.	Interboro R. T. Co.	Girders for crane runway	... ..			

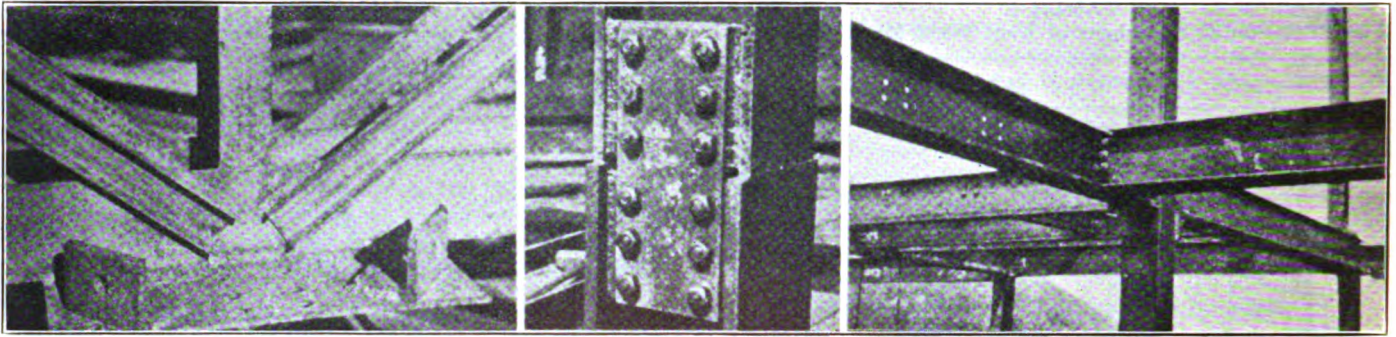


FIG. 4 (left)—Detail, General Electric Company building, Philadelphia. FIG. 5 (center)—Column splice, hotel, Hot Springs, Va. FIG. 6 (right)—Beam connections, hotel, Hot Springs, Va.

Allowable working unit values for fillet welds appear to be crystallizing at about 28 per cent of the ultimate strength under shear of the neat weld metal. This per centage assumes the depth of throat to be the minimum permitted by the gages. Thus, a value of 3000 lbs. (3 kips) per linear inch is in frequent use for the popular $\frac{3}{8}$ -in. fillet. Pending the final report of the committee, this value (under static load) seems to be suitable for properly made welds, and it further looks as if a safe value for other usual sizes of fillet can be figured on the basis of one kip per eighth of an inch of nominal size.

It will be noted that, whereas the yield point of mild rolled steel is usually a little more than half its ultimate strength, the yield point of weld metal, as shown by Table C, is from three to four-fifths its ultimate strength. This means that, with the same factor of safety as referred to ultimate strength, the weld has a considerably higher factor of safety as referred to the more critical yield point.

Perhaps the most convincing proof that unit values for the strength of welded joints can be determined is the fact that such values have been, and are now being, employed commercially in the design of a large number of important structures with entire satisfaction to all concerned. A year ago Prof. McKibben compiled a list of 55 such structures. A few examples of recent welded construction in America are cited in Tables E and F. The classification is explained in our answer to Question Six.

Is There Some Way of Determining the Reliability of the Completed Weld?

This is doubtless the most important question to be answered. All the foregoing features are secondary as compared with the question of reliability. Whether a structure be designed with unit stresses of 2000, 2500, or 3000 lbs. per linear inch of fillet weld is of little consequence unless the weld is good. On every hand one is asked, "How can we be sure whether a weld is sound? Can we eliminate the human equation?" These are natural and proper questions, and nothing is to be gained by side-stepping them.

If welding is to be considered seriously as a structural tool similar confidence in its results must be given opportunity to develop. This may be done in several ways:

1—By familiarity. Let every structural shop do some welding, no matter by what process. If there be any hesitancy regarding major joints then weld the minor ones, but install at least one equipment and use that as a nucleus. Let us become "Welding minded!"

2—By flame-cutting out short sections of weld and examining their interior. They can readily be replaced by the process of welding without detriment to the joint.

3—By occasional non-destructive tests on portions of a completed structure, with loads of, say, one and a half times those for which it was designed.

4—Most important of all, by qualification of the welder. This is very necessary, and fortunately it is both feasible and significant. The Structural Steel Welding Committee has prepared a specification for qualifying welders (Section B) whose requirements cover what may reasonably be expected in commercial practice.

5—By a proper selection of welding wire. The importance of this feature has already been emphasized in Answer One.

Can the Welding Operations be Done at a Competitive Cost?

To this question the writer would give a qualified answer. For certain classes of work, "Yes!" For other classes of work, costs so far available have been higher than for older methods of fabrication and assembly. The higher costs appear to be reflected, not so much in the expense of making the welds themselves, as in the labor involved in preparation. In certain kinds of work this labor resulted from the need of cutting rolled steel members to closer length tolerances than are the established practice at the mills. In all cases where material had to pass through a shop, costs were augmented by the fact that so far there has not been a sufficient volume of structural welding to keep a given shop continuously busy.

With fabricating shops organized along existing lines in which welded jobs are undertaken only occasionally, the following classification of work from an economic standpoint seems to represent our experience.

1—Competitive costs can be secured on low beam-and-column buildings whose details are sufficiently simple to permit the rolled steel members to be shipped unfabricated from the mill direct to the site, thereby requiring only field welding.

2—Competitive costs can be secured on certain types of shop-welded structures in which considerable savings in weight are securable, notably in truss-work wherein the net section of tension members is a criterion and where gusset plates and other expensive details can be largely eliminated. Such work is exemplified in Fig. 4.

(Continued on page 1613)

The POWER PLANT

A History of the Combustion Engine

Early Types Cited and Development Traced Leading Up to the
Efficient Mechanisms that Bid Fair to Rival the
Steam Engine as a Prime Mover

By J. H. GALLAWAY*

IN 1794 Robert Street, an Englishman, patented the first gas engine. The bottom of the cylinder of this engine was heated by fire and a few drops of turpentine were introduced and evaporated by the heat as the piston was drawn up. Air which entered the cylinder mixed with the combustible vapor and the application of a gas flame through a port caused an explosion. Although this engine was very crude, the idea was a practical one.

The next development of importance was Lebon's engine patented in France in 1799. A combustible mixture consisting of gas and air was compressed by pumps and discharged into a combustion chamber where detonation occurred. The hot gas under pressure was delivered to the working cylinder. Lebon's engine was of the double acting type and although his ideas were quite crude, the engine was the first to employ the constant pressure principle which is so prominent today in the theoretical Diesel engine.

The Brown engine patented in 1823 and 1826 was of a more practical design than its predecessors although it was uneconomical and of inordinate proportions with regard to horsepower developed. Two applications of this engine are of unusual interest. In 1826 a Brown engine with cylinder dimensions of 12 in. x 24 in. was applied to an automotive vehicle. In a test run conducted May, 1826, the vehicle ascended a grade of 13½ in. in 12 ft. In 1827 a 36-ft. boat equipped with a Brown engine made a speed of 7 to 8 miles an hour on the Thames River. In 1832 there were four water pumping engines in service.

The Barnett engine patented in 1838 marks one of the important mile stones in the development of combustion engines. William Barnett was the first inventor to adopt the system of compressing the combustible mixture before igniting it and he also invented an ignition cock that was widely used for over 50 years.

In 1855 the engine patented by A. V. Newton used a new system of ignition in the form of a hollow cast iron plug projecting into a combustion chamber that communicated with the working cylinder. A gas flame which was projected into the hollow of the plug maintained a red hot temperature of the metal, and as the piston uncovered a port between combustion chamber and working cylinder, combustion occurred. This system of firing combustible mixtures, now called surface ignition, was widely adopted in various modified forms

and is used extensively to this day. Electric spark ignition was introduced by Barsanti and Matteucci in their engine patented in 1857.

Commercial Applications Begun

The year 1860 marks the beginning of public use of combustion engines as it was in that year that Lenoir, a Frenchman, had his first engine built in Paris. This engine was designed along the general lines of existing steam engines, and although no novel ideas were incorporated in it, the practical difficulties encountered by other inventors were worked out to such an extent that 300 or 400 of Lenoir engines were in use as early as 1865, and several of them built in that year are said to be in operation today.

Beau de Rochas in 1862 made some very valuable contributions to gas engine development, as it was he that suggested the well known four stroke cycle principle on which the majority of combustion engines now operate. He seems to have had a clearer understanding of combustion and expansion of gases and the transmission of heat through water jackets. De Rochas proposed to ignite the combustible mixture by the heat generated in compressing it, which method was destined to become universally used in the Diesel engine. It is interesting to note that his proposed compression ratio of four to one for gas engines is used to this day.

Otto and Langen built their engine in 1867 using only principles conceived but rather crudely applied by their predecessors. These German engineers adopted a practice now followed by present day designers, which is to say they developed their engine. Their engine was serviceable and the fuel consumption was less than one-half that of the Barsanti and Matteucci engine, with which it was identical in principle.

All combustion engines that had been proposed or built up to this time were gas engines, but it remained for an American named Brayton to develop the first oil engine, in 1873. The engine was first developed as a gas engine, but its economy was not as high as the Otto and Langen engine, or the Lenoir engine, and this consideration induced Brayton to modify his design in order to operate it on petroleum. Mr. Brayton used a felt covered metal grating located in the cylinder head and onto which liquid fuel was delivered by a metering pump. An air compressor pumped air through the grating and the stream of air charged

*Engineering staff, De La Vergne Machine Company.

with fuel vapor absorbed in passing through the grating was ignited by the flame fed continuously by the fuel.

Otto Engine Forerunner of Present Gas Engines

In 1876 Dr. Otto brought out his second gas engine which was a great improvement over his engine of former days. He adopted the four stroke cycle principle suggested by De Roches in 1862 and worked out the details of the engine to such an extent that it soon became widely used. Gas engines of today are quite similar in principle to Dr. Otto's engine.

The Hornsby-Ackroyd engine, developed by Mr. Stewart Ackroyd, was patented in 1891 and almost immediately became widely used throughout the civilized world. Many of these engines are still being operated every day in oil pipe line service in nearly all important oil fields of the world.

The illustration shows one of these engines in Perryman Station of the Gulf Pipe Line Company near Jenks, Okla., where they were installed 21 years ago. The Hornsby-Ackroyd engine was the first engine to be equipped with a practical surface ignition or hot ball system of ignition which is sometimes called semi-Diesel. Liquid fuel under pressure was injected through an atomizer and against the hot surface of a vaporizer or hot ball which was heated by a torch before starting the engine, the high temperature being maintained thereafter by combustion in the cylinder. Compression pressure was about 40 lb. per square inch and the injecting mechanism was timed in such a way that injection occurred during the suction stroke, the fuel pump being actuated by the air inlet lever. The four stroke constant volume or explosion cycle was employed.

The Hornsby-Ackroyd engine was introduced in America in 1893 by the De La Vergne Machine Company as licensees. It was the first commercially successful oil engine in the world and the forerunner of the now well known Diesel engine.

The system of injecting fuel by means of an independent pump placed the engine in an entirely different field compared with its predecessors as it permitted the use of a wide range of inexpensive liquid fuels and omitted the carburetor and the electric ignition, parts which caused the most difficulties in those days. The ignition of the Hornsby-Ackroyd engine was timed by the size of the vaporizer and the temperature and size of the hot cap. If the fuel of a different characteristic had to be burned a change of vaporizer and cap was often necessary which was costly and complicated. In order to make the engine adaptable for different fuels and to reduce the fuel consumption, the oil was injected during the compression stroke and the compression pressure was increased.

Types Diverge Into Three Classes

At this point it may be well to digress for a few moments to discuss some of the fundamental principles of combustion engines. The true working medium of any internal combustion engine is atmospheric air and in a broad sense the different types of engines vary only in the methods employed to introduce fuel into the cylinder where it is burned for the purpose of causing the entrapped air to expand behind a piston, thereby performing useful work. There are three major types of combustion now in general use.

1—The constant volume type in which the working medium or air in the cylinder is heated at constant volume with an increase of temperature and an increase of pressure. This cycle is used in Hornsby-Ackroyd engines, in gasoline engines of the automotive type and in those included in this general classification.

2—The constant pressure type in which the working medium is heated at constant pressure and constant temperature with an increase in volume and a decrease in pressure. This cycle is employed in the theoretical Diesel engine but there is a tendency toward modification of the Diesel cycle along lines that somewhat approach the constant volume or explosion type.

3—The Sabethe type which employs a combination of the constant pressure and constant volume cycles.

In 1893 Dr. Rudolph Diesel published a paper in which he specified the principles of an engine that would operate on a wide range of cheap fuels and at a very high thermal efficiency. He sought to realize these objects by adopting the following working principles:

1—Compressing pure air in the cylinder to a high pressure in order to produce the highest temperature of the cycle before introducing fuel.

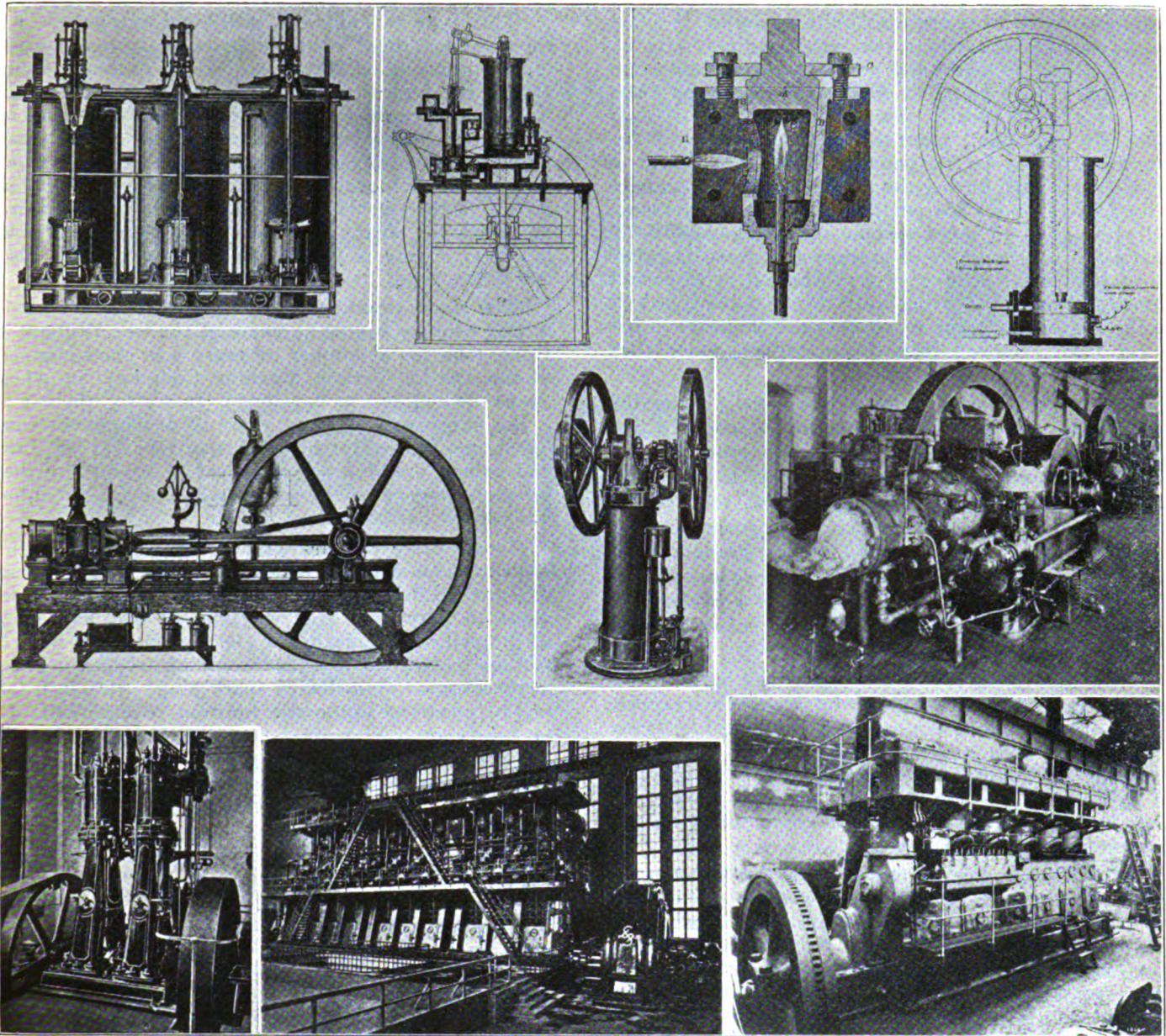
2—The slow injection of fuel into the highly compressed and heated air in a manner that would insure isothermal combustion or combustion at constant temperature and by adjusting the proportions of air and fuel to eliminate the necessity of water cooling. He proposed to compress the air in two stages in order to obtain both isothermal and adiabatic compression.

The first stage of compression from atmospheric pressure to about 28 lb. was to be isothermal or without increase of temperature and the second stage from 28 lb. to about 350 lb. was to be adiabatic or without cooling. His first idea was to operate the engine on powdered coal, but after experimenting for several years, the engine was so modified as to show very little resemblance to the engine originally proposed and it was found that it could not be operated on anything but liquid fuel.

After making many thermodynamic and mechanical changes, the first public experiments were made in 1897. In 1898 three Diesel engines were exhibited in Munich and a two cylinder 60 hp. engine built in this country was installed in the Anhauser-Busch Brewery in St. Louis. From that time, the commercial application of Diesel engines commenced.

The thermal efficiency of the Diesel engine is higher than that of any other type of heat engine. A fuel consumption of .4 lb. per bhp. is quite common even in engines of small cylinder sizes and with fuel having a calorific value of 18,500 Btu. per pound, this represents actual thermal efficiency of 34.4 per cent, assuming a mechanical efficiency of 78 per cent and a brake mean effective pressure of 75 lb. per square inch, which represents an indicated thermal efficiency of 44.2 per cent.

Because of the short time interval of fuel injection, which occurs over 10 per cent to 12 per cent of the working stroke, and difficulties of obtaining a thorough distribution or mixing of the fuel with the air, Diesel engines are usually designed to take in 75 per cent to 100 per cent more air than is theoretically



(Top row, left to right)—The Brown engine. The Barnett engine. The Barnett ignition cock. Barsanti and Mattencci engine.
 (Center row, left to right)—The Lenoir engine. Otto and Langen engine. Type "HA" engine at Perryman station.
 (Bottom row, left to right)—First American Diesel engine. 15,000 hp. Blohm and Voss engine. 1,125 hp. De La Vergne engine.

required to burn the fuel. By reducing the percentage of excess air required to burn the fuel, the thermal efficiency of the engine itself will not be materially improved in the immediate future although consideration is now being given to the utilization of the heat in exhaust gases to generate steam for application to the piston on the order of a double acting cylinder, one end of which operates on the Diesel cycle and the other end on a steam cycle.

An engine of this type has actually been built in England but no consideration has been given it in this country for the reason that we have an abundance of cheap fuel which makes the further improvement of thermal efficiency relatively unimportant. Reliability and low cost of maintenance are the two problems that have been given the utmost consideration by American Diesel engine builders and so much has been done to improve the Diesel engine in these respects that the engine is now considered as reliable

as any other type of prime mover, not excepting steam engines.

In a small municipally owned electric plant at Ashland, Kan., an engine recently completed a non-stop run of 457 days or one year and three months which is thought to be a world's record for continuous operation of any type of prime mover.

Features in Development of the Diesel Engine

In the early days of Diesel engine use, the maintenance cost was excessive in many cases but this was largely the result of incorrect design of some parts, incorrect installation, overload conditions and incompetent operators. Cylinder head failures and crankshaft failures were quite common but modern engines are so designed that these troubles rarely occur in plants where non-scale forming cooling water is used and where operating conditions are such that the engines may be given proper attention. Unusually low

maintenance records are now quite common. A plant in the middle west where two small engines were installed about 10 years ago and where two larger engines have been installed during the past four years has an average yearly maintenance record of only \$290. In one small plant consisting of two 130-hp. engines driving electric generators, the actual cost of repair parts used during the past seven years has been only \$377 or about \$54 per year. This plant was carefully designed to meet specific operating conditions, that is to say, engines of correct size were installed and a soft water cooling system was put in to permit of using non-scale forming water in the cooling jackets of the engines with the result that a cylinder head has never been removed from these engines since they were put in seven years ago.

The life of a Diesel engine is now usually estimated at 25 years and there are a number of engines that have been in service that long. Shop production of complete engines and spare parts which has been standardized to a very large extent has reduced the first cost of engines and has materially lowered maintenance expenses. The first cost of high grade engines of popular sizes varies from \$50 to \$60 per horsepower at the factories and all moving parts of a modern engine can be replaced for about 20 per cent of the first cost of the complete engine.

Of a total of 1,155,755 hp. of engines built in this country up to 1926, only 20,000 hp. has been scrapped, which proves its inherent qualities and long life. Many efforts have been made to cheapen the engine by lowering the quality of workmanship and by adoption of inferior designs but in nearly all cases these practices have resulted in failures. In commenting on this subject in 1911, Dr. Diesel said:

"The Diesel engine motor must be constructed with extreme care and the best materials employed in order that it may properly fulfill all its capabilities. Only the best and most completely equipped works can build it. The Diesel engine is, therefore, not a cheap engine and I would add a warning that the attempt should never be made to try to build it cheaply by unfinished workmanship. These fundamental conditions are no less advantageous as has been frequently proved; on the contrary, they are precisely the reason of its strong position and form a guarantee of its worth."

Diesel engines may be classified under the following headings: Four stroke cycle; two stroke cycle; air injection; single acting; double acting; Junkers opposed piston type; and Camillard-Fullagar type.

Fuel Injected Mechanically

Dr. Diesel originally conceived an engine in which fuel injection would be accomplished by mechanical means, that is to say, by a pump delivering fuel through an atomizing device that would break up the oil and distribute it in a finely divided state in the highly compressed and heated air in the cylinder. After considerable experimental work he modified his engine and adopted the idea of atomizing the oil by means of air compressed to a higher pressure than the compression pressure in the main working cylinder. A mechanically operated fuel valve was used to time the injection and fuel oil was forced into the cylinder by means of air pressure.

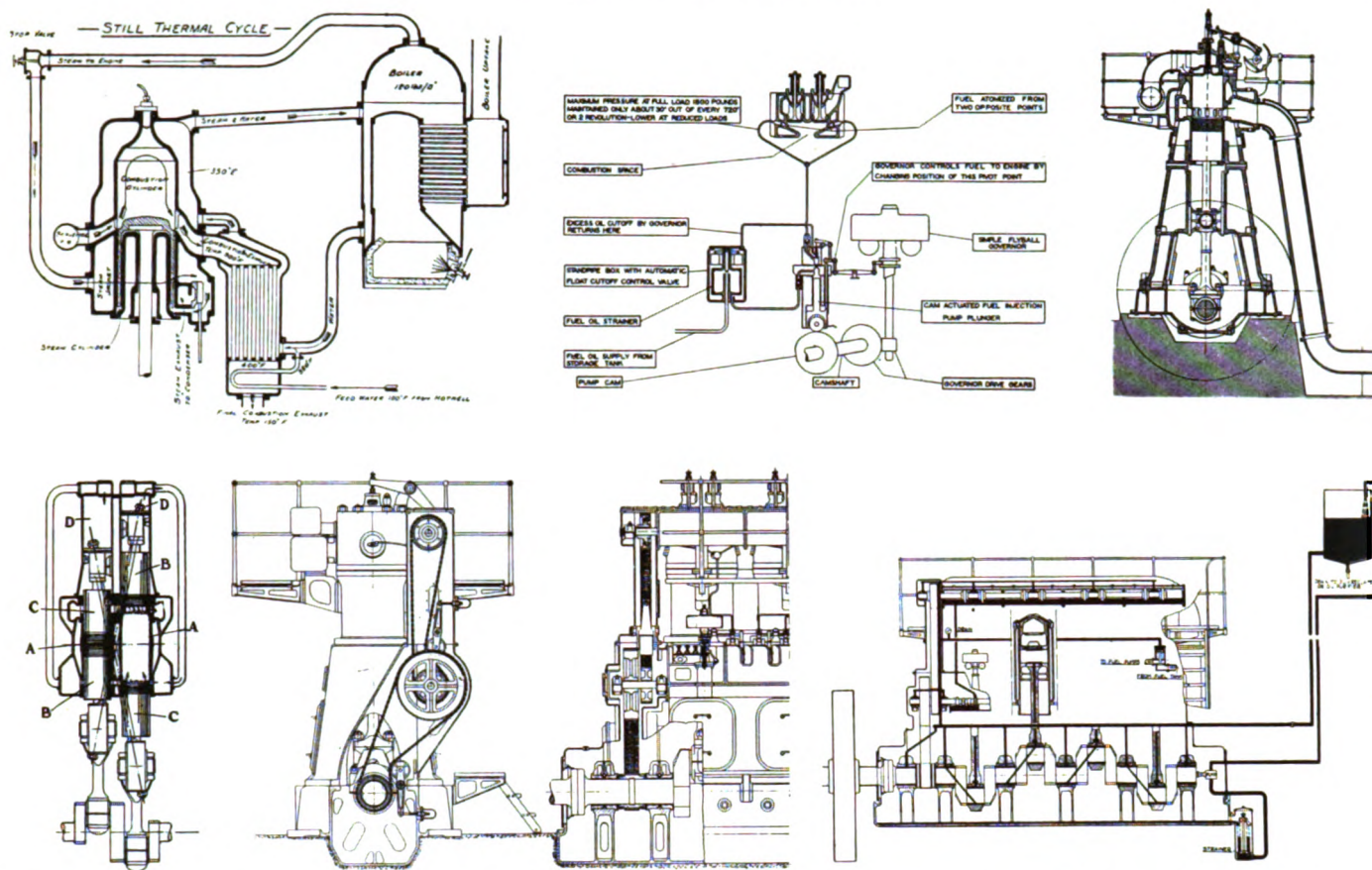
This type of engine is still used extensively but the complication of a three stage air compressor working at pressures of 700 lb. to 900 lb. per square inch and of the high pressure piping and air bottles, etc., has induced engineers to devote a great deal of attention to simplification and improvement of the otherwise splendid Diesel engine. These considerations brought about development of the so-called solid injection engines in which fuel is injected by mechanical or hydraulic means and today the four cycle solid injection engine is gaining in popularity faster than any other type.

The most prominent solid injection system built in this country bears the name of the late William T. Price, who for a number of years was chief engineer of the De La Vergne Machine Company, in whose shops the engine was developed. In reality, the engine is the outgrowth of many years of development work on engines of the Hornsby-Ackroyd type but Mr. Price and others are due a great deal of credit for their foresight and perseverance. The first of these engines was placed on the market in 1918.

These early engines were designed for operation on compression pressures of 180 lb. to 260 lb., which did not produce sufficient heat due to compression alone to permit of cold starting so this had to be accomplished by means of electric current from a storage battery and a Nichrome-nickel heating coil in the form of an ordinary spark plug. Although failing to meet the automatic ignition requirement, due to low compression pressure, the Price or De La Vergne engine came nearest to meeting Dr. Diesel's specifications in regard to overall efficiency.

When two curves are drawn, one representing thermal efficiency at various compression pressures and the other representing mechanical efficiency of an engine operating on these pressures, and as the overall efficiency is a product of the two, it will be found that maximum overall efficiency is attained with compression pressure ranging between 240 lb. to 360 lb. 240 lb. compression pressure does not provide sufficient heat to insure automatic ignition but the theoretical temperature of air compressed to 360 lb. is about 890 deg. F., which is considered a safe margin above the temperature required to ignite all commercial grades of fuel oil. The attainment of maximum efficiency by means of high compression seems to have been Dr. Diesel's primary object with automatic ignition as a secondary consideration.

After several years of further development work, compression pressures of 330 lb. to 360 lb. were adopted and most solid injection engines built today operate on that range of compression pressures with maximum working pressures ranging from 500 lb. to 550 lb. Compared with the air injection engine, the solid injection Diesel has a slightly lower thermal efficiency due principally to the fact that it takes in a larger percentage of excess air over the theoretical quantity required to burn the fuel but it has a higher mechanical efficiency because of absence of the air compressor that the air injection engine must drive and the fact that air injection engines are designed to operate on compression pressures ranging from 450 lb. to 500 lb. which are necessary to develop temperatures high enough to offset the refrigerating effect of the injection air expanding from a higher pressure than that in the cylinder. The overall efficiency is



(Top row, left to right)—Still engine. De La Vergne solid injection system. Power cylinder of Nordberg Diesel engine, two cycle. (Bottom row, left to right)—Cammellaird-Fullagar engine. De La Vergne chain drive on VA and VB engines. De La Vergne lubricating oil systems.

about the same in both types and because of simplicity and satisfactory performance of the solid injection engine, many builders are turning out engines of this type in sizes as large as 6,000 hp., in single acting, double acting and opposed piston designs.

There is no general agreement among designers as to the relative merits of the various types of engines now being built. The air injection engine has its champions and those who oppose this type concede that it is a satisfactory power unit. Those who favor the solid injection engine are usually familiar with the advantages and disadvantages of the air injection engine and insist that simplicity and the same overall economy more than offset the small difference in thermal efficiency in favor of the air injection engine. Both types will operate satisfactorily and both sides concede that point. Likewise the four cycle and two cycle engine designers have their differences of opinion but here again, there are advantages in both types although it must be said that the world's most prominent builders of marine Diesel engines, Burmeister & Wain of Denmark build four cycle engines exclusively and in their larger sizes such as the 6,750 hp. engines in the motorship "Gripsholm" and the two 10,000 hp. engines in the motorship "Alcontara" the double acting principle has been adopted.

Two Cycle versus Four Cycle Engine

The two cycle engine will develop more power than a four cycle engine of the same cylinder size but the problem of cooling the cylinder heads, cylinder walls and pistons is not easily solved. The two cycle engine must burn nearly twice as much fuel in

a cylinder of a given diameter and the cylinder must be scavenged with air compressed to 2 lb. to 4 lb. per square inch by pump or compressor.

In some two cycle engines scavenging air is admitted to the cylinder through mechanically operated valves in the cylinder head while others have one, and in some cases, two rows of ports in the cylinder wall through which scavenging air is admitted. Efficient scavenging presents quite a problem and it has not been entirely solved although there are a number of very successful two cycle engines in service. As two cycle double acting principles permit development of the greatest horsepower in a cylinder, it is only logical that very large engines should be designed along these lines. The largest Diesel engines ever built are of this type. In 1917 the M.A.N. Company of Germany completed and tested a 6 cylinder double acting two cycle engine rated at 12,000 hp. but which developed 17,150 hp. on test. The cylinder dimensions were 34.45 in. x 41.34 in. and the speed was 110 r.p.m. This engine was designed for use in battle cruisers but the surrender of the German fleet in 1918 put an end to these plans and a short time after the war, the Allied War Commission ordered the destruction of the engine on the ground that it was intended for military uses.

The largest Diesel engine in existence is installed in a Central Electric Generating Station in Hamburg, Germany. The engine is rated at 15,000 hp. and has nine double acting cylinders that operate on the two cycle principle. The cylinder dimensions are 33.86 in. x 59.05 in. and the speed is 94 r.p.m. The overall dimensions are: length 80 ft., width 14 ft. 1 in., height

above shaft center 32 ft. 8 in. Blohm and Voss of Hamburg are the designers and builders.

The two cycle principle presents possibilities of great reduction in the weight and when combined with the double acting principle, still greater reductions in weight are possible compared with engines of the four stroke cycle type. Some of the most prominent builders of four cycle engines have adopted the double acting principle in order to reduce weight and floor space requirements which are very important considerations in marine and submarine installations.

Other comparatively recent modifications of the Diesel engine include the Junkers opposed piston and the Commellaird-Fullagar types. The Junkers opposed piston engine is now being built in England by Doxford and in this country by the Sun Shipbuilding Company. This engine has two pistons and three cranks per cylinder. The pistons work in opposite directions, the upper piston being attached to a yoke which drives two cranks through connecting rods, one connected with each end of the yoke. The engine operates on the two cycle principle and exhaust and scavenging ports are located at opposite ends of the cylinder. When the pistons reach the end of the expansion stroke, one piston uncovers the exhaust ports and the other uncovers the scavenging ports, thus affording a comparatively straight path for the travel of scavenging air. There are no cylinder heads on this engine and the only valves used are the fuel and air starting valves.

Fuel is injected through two mechanically operated fuel valves located on opposite sides of the cylinder and at right angles to its axis. Being of the solid injection type, proper fuel distribution is not easily accomplished but the designers have worked this out pretty well as evidenced by the fact that a large number of these engines of larger sizes have been in satisfactory operation for several years. Henry Ford has about a half dozen 2,500 hp. and 3,000 hp. engines of this same type in his private yacht. The Kerr interests have several of these engines in fast freight ships operating between our west coast ports and the Orient. Some of these ships travel about 17 miles per hour and are equipped with only one propelling engine of 6,000 hp. in four cylinders, indicating that the owners have complete confidence in the reliability of the Diesel engine.

The Commellaird-Fullagar engine is a modification of the Junkers or Doxford engine. Opposed pistons are used but the cross-heads of the upper pistons are connected through angular rods with the lower cross-heads of the other cylinders. The cross-head guides of the upper pistons are closed in and although of rectangular section, are fitted with pistons and suitable packing devices for compressing scavenging air. This engine, like the Doxford, is of the solid injection type.

Importance of the Diesel Engine

The many types of Diesel engines now being built indicate the healthy condition of the Diesel engine industry as active and energetic rivalry among the various builders is resulting in the production of better and more reliable engines every year. Because of economic reasons, much more progress has been made in the development of large engines by European builders but American engines in sizes being built here are second to none in reliability of performance and in over all economy.

Light weight engines of relatively high speed are now being produced in this country for locomotives, shovels, tractors, drag line excavators, yachts, logging machines, etc. Engines as small as $7\frac{1}{2}$ hp. per cylinder and running at speeds up to 900 r.p.m. are on the market.

There is a German built Diesel engine motor truck in service in New York and a small cylinder high speed automotive type engine is being offered here for similar classes of service. The future of the Diesel locomotive seems very bright. Several locomotives of 300 to 400 hp. are now used in switching service in New York and Chicago and larger locomotives are under construction. The transmission problems of the locomotive was at first thought to be a serious one but it seems to have been solved by the adoption of the electric system.

What the future holds for the Diesel engine industry of this country will, to a large extent, depend upon future economic developments. The high grade American engines have established themselves as thoroughly dependable and economically operated power units. Improved methods of production, refinements of design and, to a large extent, simplification has made the Diesel engine a formidable competitor of all other types of prime movers.

Endurance Is High

It is an established fact that Diesel engines have a useful life equal to, if not greater than steam engines with the added advantage that the obsolescence factor due to "improvements in the art" is of very little consequence as the Diesel engine is not likely to be supplanted by a more efficient engine, not even a more efficient Diesel engine. "Obsolescence due to inadequacy" is minimized by the fact that a 100-hp. Diesel is about as efficient from the thermal point of view as an engine 10 times that size, so regardless of the necessity for expansions of plant capacity, the small units can usually be operated to advantage. The fuel consumption curve being practically flat from one-half load to full load makes the engine unusually attractive in plants where the load fluctuates widely.

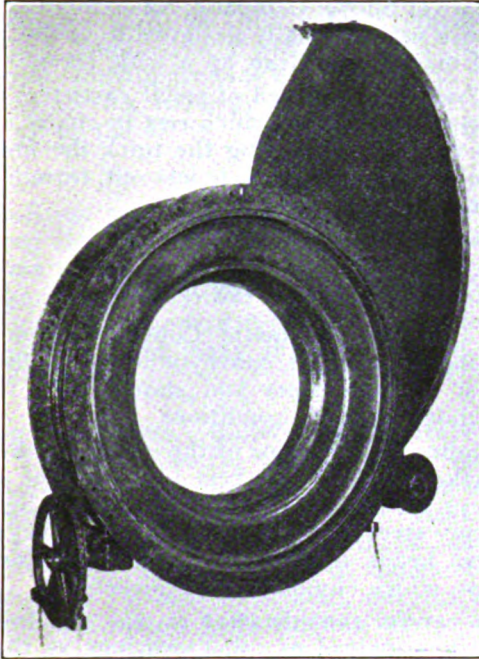
Improvements in design and metallurgy of important working parts are usually applicable to existing engines, as witness the fact that one builder developed a solid injection system and applied it to over 325 existing air injection engines. Even Hornsby-Ackroyd engines built over 20 years ago have been modernized by the application of cylinders designed for higher compression pressure and operating on the solid injection system.

Designs of the major American Diesel engine builders generally have been developed to the point where engines built at the present time may confidently be expected to give a good account of themselves over a long period of years and under the most exacting conditions of operation. Having worked out successful designs as proven by performance of engines in service, American builders are devoting a great deal of attention to refinements, simplification and close limits of workmanship. The pistons, cylinder heads and cylinder liners of some engines are made of a high grade of gray iron melted in electric furnaces in which impurities of the iron can be controlled within very narrow limits. These parts are then carefully annealed to remove casting stresses.

WITH THE EQUIPMENT MANUFACTURERS

Description of Goggle Valve

A new type of goggle valve has recently been developed and placed on the market by Edgar E. Brosius, Inc., Sharpsburg, Pa. This is a self-contained, hand-operated valve, mechanically stronger than the line in which it is mounted, so that it may be placed anywhere in the line regardless of support.



It is an electric-welded unit and is delivered to the purchaser ready to bolt into the gas line, no extra provision or additional cost of any kind being necessary.

Angle flanges are provided and drilled to suit the purchaser's flanges, or vice versa. The valve is fast in operation and can be motor-driven if desired. The sealing pressure is obtained by the wedging or cam action between a circular pipe, a round rod, and a square section valve seat. This is accomplished by opposed bronze nuts and stainless steel screws, driven by a hand wheel and worm gears. Expanding the pipe opens the valve and contracting the pipe closes the valve.

Due to the flexible cam action of the pipe between the round rod and square valve seat a uniform pressure throughout the circumference of this seat is obtained.

Due to using a flexing plate for the moving seat it is possible to open this valve through 1 in. for the purpose of removing the goggle plate should it become buckled in any manner.

In addition to the heavy sealing pressure for closing the valve tight there is also supplied an oil seal which consists in forcing a high temperature resisting oil around an annular groove in each sealing ring, this oil closing any slight leak which may develop due to abrasion of the valve seat or inequality in the thick-

ness of the goggle plate. This oil also preserves the surface of the goggle plate, preventing pitting from corrosion and rust.

The goggle plate itself is swung in the conventional manner by means of a rope around the outside edge of the plate and hand-power worm-driven drum. All three worm drives are enclosed in grease-tight cases and the worm gears are machine cut.

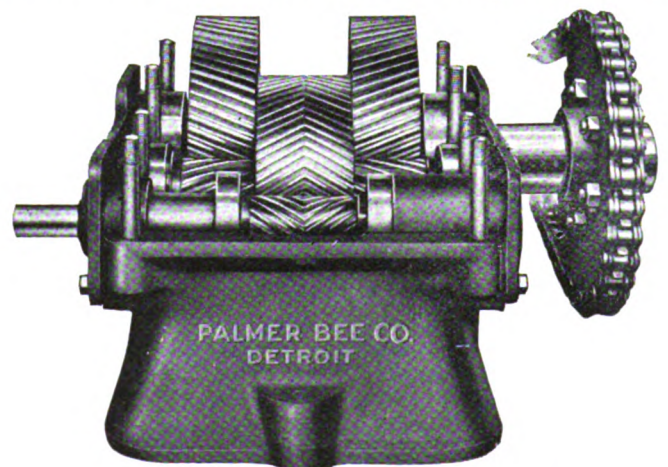
New Line of Herringbone Speed Reducers

Palmer-Bee Company, Detroit, has just placed on the market an entirely new line of herringbone speed reducers. This series has been added in order to meet the ever-increasing demand for still stronger, more modern and efficient enclosed gear reduction units.

Anti-friction bearings are used throughout; ball bearings on the high speed, Hyatts on the intermediate and Timkens on the slow speed shaft. Gears are continuous-tooth herringbone, with silent Kysor tooth form, producing more rolling and less sliding action than heretofore has been obtainable. The slow speed gears in the double and triple series are divided in the center, permitting a more symmetrical arrangement of the gearing and a uniform load on each bearing.

Following the universal practice of the automotive industry in using the three-point method of mounting motors in chassis, the Palmer-Bee Company has adopted this method in bolting the reducer to the sub-base. Alignment of the various elements of the drive are thus facilitated.

No outboard bearings are required for overhung loads up to the maximum rated capacity of the reducer. This feature is one of no little importance when



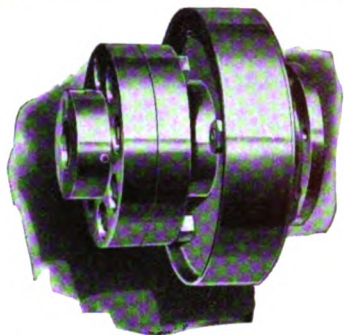
the additional expense and inconvenience of including them in certain drive layouts is considered.

The efficiency of the single series reducers is approximately 99 per cent, and of the double series about 97 per cent. An illustrated folder describing the salient features can be obtained for the asking from the manufacturers.

James Combination Automatic Backstop and Flexible Coupling

The James automatic backstop is designed for use on elevators, conveyors and process equipment drives where there is a likelihood of reversal of travel when equipment is standing idle or when the motor has been shut off after a day's run, or in case of motor failure.

This unit consists simply of a drum shaped housing, on the back of which is integrally made one-half of a flexible coupling, which contains free flexing, live rubber bumpers, and in which are cemented bound brook oilless bushings. A one-half coupling fitted with hardened and ground steel pins which float inside of



the graphite impregnated bronze bushings, a ratchet plate, 3 pawls with studs, springs and fastening bolts and a two-piece cover plate complete the unit.

There are no friction surfaces or wearing parts, and unlike other devices intended for the same work, the James automatic backstop does not wear out and become inactive after a few months of hard service. Because of the unique construction, this unit will wear indefinitely, and require no care, attention or maintenance.

The backstop is applied on the drive shaft between a speed reducer and motor. A flange, attached to the speed reducer housing, is cast integral with a ratchet. This ratchet operates within the drum housing which in turn is connected to the motor shaft through a flexible rubber bumper type coupling. On the inner face of the housing 3 pawls are secured by the medium of studs which engage with the ratchet the moment the housing stops revolving.

One flange of the flexible coupling is cast integral with the drum housing, thus lending compactness and strength.

Centrifugal force keeps the pawls out of engagement with the ratchet during operation, but should anything happen to the shaft or motor, or should the motor be purposely shut off so as to halt the driven unit, the pawls, as can be easily seen, engage with the ratchet through gravity, and provide a complete brake against reversal of travel of the elevator or driven machine.

Large capacity bucket elevators and conveyors, as used in grain elevators, mills, crushed stone, sand and gravel, cement, brick and clay plants, and in numerous other industries for materials handling, can be easily held in position without fear of their backing up by using a James automatic backstop.

This unit finds an ideal application as a brake against heavy loads on all driven machinery where there is always great danger from loads running back-

wards and causing damage. A recent break-down brought to our attention resulted from a 42-in. wide bucket elevator, 106 ft. high, handling crushed stone, which because of overload, ran backwards and completely destroyed the entire elevator.

If you have in mind applications or uses for this equipment other than those mentioned, and where reversing loads or recoil shocks would cause damage, this unit may be adapted to your particular conditions.

Reach the Wide Places with Flexible Rail

Wide places may be easily cleaned up with a single track if the Clarkson flexible rail, manufactured by the Illinois Power Shovel Company, Nashville, Ill., is used. This device was originally designed to enable a track-mounted machine to clean up a wide room.

The "rail" is composed of small cast-steel sections with stop ears attached, which rest in chairs mounted on cross ties. Upon moving the track the inside sections contract and the outside lets out, forming a uniform curve.

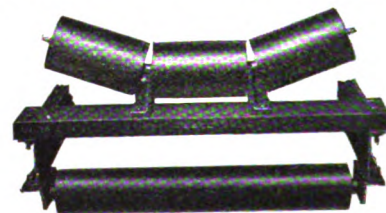
Belt Conveyor Idler

The Chicago Automatic Conveyor Company is announcing a new belt conveyor idler. It has all of the latest improvements and should give life time service under ordinary conditions.

The following are some of the improvements which go to make it one of the best idlers on the market; the pulleys are spaced $\frac{1}{4}$ in. apart to avoid belt creasing. Heavy steel tubing is used for the pulleys. They have steel heads which are electrically-welded flush with ends, which eliminate dust pockets.

After careful consideration it was decided to use ball bearings instead of roller bearings as they were found to be much more efficient. Another point in favor of ball bearings is that they do not have to be adjusted.

A unit mounting is used for the bearings to keep them in perfect alignment. The mounting also serves as a grease reservoir. Because of the large reservoir



the idlers will run from three to six months without attention. The bearings are positively protected from dust and grit by a quadruple labyrinth grease seal. This seal also prevents the grease from being thrown on the belt.

Heavy cast iron brackets are used. They are accurately machined to avoid cramping the shaft, and can be mounted on either wood or channel base.

There are only three places to lubricate each idler. These are fitted with alemite fittings or other types of high pressure fittings to suit plant standards.

This idler is being manufactured on a production basis resulting in surprisingly low prices being quoted.

TRADE PUBLICATIONS

The D. O. James Manufacturing Company, 1120 West Monroe Street, Chicago, have just completed and published their Speed Reducer Catalog No. 166 which describes, illustrates and lists completely every type of speed reducer made—planetary spur (direct, angle and vertical drives); heavy duty worm (direct and angle drives); medium duty worm (direct and angle drives), and herringbone (direct and angle drives).

This book should be of extreme value to all engineers interested in speed reducers in that it is the only complete work on this subject; further, it is written and compiled in a simple, concise, well illustrated form which makes for easy reference.

A copy of this 160-page catalog may be obtained by writing to the D. O. James Manufacturing Company.

* * *

Blaw-Knox standard buildings of copper bearing galvanized steel "serving all industries" furnishes the subject matter of an attractively illustrated pamphlet of 38 pages issued by the Blaw-Knox Company, of Pittsburgh, Pa. Standard types are shown in dimensioned sketches and many installations are depicted in the illustrations.

* * *

"Sangamo Meters," Bulletin 74, illustrated, issued by the Sangamo Electric Company, of Springfield, will make clear to you the construction and operation of the watt hour meter and contains diagrams and tables as well as price lists. Bulletin 69, illustrated, explains the use and operation of Sangamo distant dials. Bulletin 73, also illustrated, devotes 31 pages to switchboard meters both a.c. and d.c.

* * *

Flexo Supply Company, of St. Louis, feature "Flexo" joints on presses and other installations where flexible connections with piping systems are required. In a folder illustrating many installations using the joints.

* * *

"Longitudinal Drum Water Tube Boilers," is the title of a catalog issued by the Union Iron Works, of Erie, Pa. The book is very well illustrated showing pictorially the construction details described as well as views of completed installations of the Union water tube boilers.

* * *

Erie City Iron Works, Erie, Pa., are distributing two booklets, one describing the Erie City economic boiler, semi-portable, and the other, return tubular boilers. Both pamphlets are fully illustrated and show typical installations including specification data and performance tests.

* * *

Bulletin No. 2003, "Penn-Lehigh Crushers," and No. 2004, "Pennsteel Crushers," are being distributed by the Pennsylvania Crusher Company, Liberty Trust Building, Philadelphia, Pa. Full description and dimensions are given and the main points of practical advantage set forth.

* * *

"Farrel-Sykes Roller Bearing Type Speed Reducers from 1 hp. to 5000 hp." is the title of an illustrated

booklet of 24 pages recently distributed by the Farrel-Birmingham Company, Inc., of Buffalo, N. Y. The pamphlet includes gear data and various tables and describes a piercing mill drive of 300 to 10,000 hp. and the Sykes gear generators.

* * *

"Silent Gears," a 32-page illustrated booklet from the General Electric Company, Schenectady gives much information and specification data regarding "fabroil" and "textolite" gear material and noiseless gears.

* * *

The Steubing Cowan Company, of Cincinnati in collaboration with their railroad representatives, Leeds, Tozzer & Company, Inc., 75 West Street, New York, have just issued an interesting pamphlet entitled "Straight Line Trucking," which describes the use of the lift truck platform system by railroads and other common carriers. The book consists of 16 pages and shows numerous reproductions of photographs illustrating the handling of materials in the stores department and machine shops and the handling of freight at railroad and steamship terminals. A copy of this pamphlet will be mailed free to anyone upon request.

* * *

"A Handbook of Small Belt Drives," issued by the L. H. Gilmer Company, Tacony, Philadelphia, Pa., discusses the use of belts of rubber and cord fabric for power transmission, with special reference to the application of V-belts to short center and high speed drives. Engineering data are given for use in designing V-belt drives and numerous illustrations show Gilmer belts on a wide variety of machines. The manner in which Gilmer belts are built up with the cords along the neutral axis of the belt, where internal friction is at a minimum, is shown by a cross section of the belt which forms a feature of the striking cover design. The book will be sent to executives who request it from the L. H. Gilmer Company.

* * *

The American Manganese Steel Company calls attention to an error on page 1345 of the October issue which included description of booklets on PyraSteel and EvanSteel. The products of the company mentioned are the Amsco manganese steel castings, Fahr-alloy heat resisting and corrosion resisting castings and special alloy steels.

PyraSteel and EvanSteel are products of the Chicago Steel Foundry Company whose booklets describing these alloys were wrongly included in the paragraph.

Book Review

Impurities in Metals. Colin J. Smittrells. 157 pp. John Wiley & Sons, New York. Price \$5.00.

Covers recent investigations into the effect of small quantities of foreign substances upon the properties of metals and alloys, and is contemplated with reference not only to theoretical considerations but to applications in the problems of manufacture. Methods for studying metals are described including X-ray analysis. Influences of such minor constituents are traced as affecting structure, mechanical properties, electrical properties and corrosion. The author is a member of the research staff of the General Electric Company, Ltd.

TRADE NOTES

The American Sheet & Tin Plate Company have contracted with The Rust Engineering Company for the construction of a Kathner type sheet normalizing furnace to be built at their Vandergrift works. This furnace is to be 155 ft. long and 84 in wide, natural gas fired and of 120 tons per day capacity. Removable cast iron and steel bungs will be used throughout the length of the furnace to provide easy access to the alloy rolls and shafts. Delivery of this furnace will be made in five weeks.

* * *

A new Prest-O-Lite gas plant located at 3155 Twenty-seventh Avenue N., Birmingham, Ala., commenced operations October 16, 1928. This plant will supply the local demand for dissolved acetylene used in oxy-acetylene welding and cutting. With this addition, the Prest-O-Lite chain now numbers 34 acetylene producing plants situated in industrial centers throughout the country.

Mr. A. J. Topham is plant superintendent and Mr. G. A. Andrews, whose headquarters are at the same plant, is district superintendent.

* * *

Recent orders taken by the Sutton Engineering Company include two 60 in. high grade sheet levellers for the Fisher Body Corporation, one non-ferrous rod straightener for the American Mond Nickel Company, five welded tube straighteners for the Steel and Tubes, Inc., subsidiary of the Republic Iron & Steel Company; one large seamless tube straightener for the Pittsburgh Steel Products Company, one angle straightener for the Steel Company of Canada through Mackintosh-Hemphill Company, and one butt weld pipe straightener for the Spang, Chalfant & Company, Inc.

* * *

The New York sales office and display room of The C. F. Pease Company, Chicago, formerly located in the Grand Central Terminal, New York City, has been moved to new quarters occupying the entire seventh floor, Ashforth Building, at 12 East Forty-fourth Street, New York City. Because of the increased floor space in this new location, this office, under the direction of Mr. T. K. Murney, eastern sales manager, has improved facilities for stock and display of a complete line of "Everything for Blue-Printing" and drafting room furniture. Also an increase in sales personnel has made it possible to more efficiently serve the entire eastern coast trade in connection with requirements for blue-printing machinery, blue-print paper, and drafting room furniture.

* * *

The National Flue Cleaner Company, Inc., of Groveville, N. J., manufacturers of the National soot blower for return tubular boilers, announces the appointments of three new Ohio sales representatives, namely Craun-Liebing Company, of Cleveland; Dennis Engineering Company, of Columbus, and the Bishop Engineering Company, of Cincinnati.

Other recent appointments are the Power Plant Efficiency Company, of Indianapolis, Ind., and the Rathburn Company, of El Paso, Texas.

Petty & Wherry, Inc., 50 Church Street, New York City, have just been appointed metropolitan distributors for the Buckwall Engineering Company, of Brooklyn, N. Y., manufacturers of the well known Buckwall sprocket wheel.

* * *

A new acetylene plant at East Avenue and Short Street, South Charleston, W. Va., bringing the total number of Prest-O-Lite plants throughout the country up to 35, started producing on October 29. Dissolved acetylene for welding and cutting will be supplied to local industry from this point.

Mr. J. J. Robinson is in charge of the plant and Mr. S. P. Murphy, whose headquarters are at Cincinnati, is district superintendent.

* * *

The steady increase in the demand for the products of The Timken Roller Bearing Company has necessitated a radical expansion in its production facilities. The complete program that has been put into effect will provide the necessary equipment for raising the company's present output of 175,000 bearings per day to over 200,000 per day. The program has necessitated the expenditure of about \$6,000,000 during the current year and covers additions to both the steel mill and bearing factory.

Steel producing facilities now in operation have increased the capacity of the plant to 30,000 tons per month of high grade open hearth and electric alloy steels. They include additions to the mill at Canton and the purchase of the plant and equipment of the Weldless Tube Company, of Wooster, Ohio.

Work has been started on various extensions to the bearing factory for the machine equipment needed to take care of the increase in the production schedule.

Open Hearth Problems Discussed

A comprehensive program of subjects bearing upon open-hearth furnace design, operation and maintenance was discussed at the two-day session of a branch of the American Institute of Mining and Metallurgical Engineers held in the William Penn Hotel, Pittsburgh, on November 15 and 16. The sessions, which were attended by about 75 open-hearth furnace superintendents, engineers and metallurgists, were presided over by L. F. Reinartz, of the Youngstown Sheet & Tube Company.

At the morning session on November 15, furnace construction was the main topic discussed. Under this heading were the following subheads:

- 1—Water cooling of furnaces.
- 2—Charging equipment.
- 3—Methods of accounting for costs of furnace repairs.
- 4—Organization.
- 5—Advantage of Loftus checker brick.
- 6—Description of Steven's furnace.
- 7—Progress report on open-hearth ports.
- 8—Progress report on burners and atomizers.
- 9—Progress report on furnace insulation.

Quality control received consideration at the afternoon session, and at the morning session on November 16, furnace operation proved an interesting feature. The meeting was terminated by a visit to the Edgar Thomson Works of the Carnegie Steel Company.

NEWS OF THE PLANTS

The two triple fired continuous furnaces built by The Rust Engineering Company for the Timken Roller Bearing Company, at Canton, Ohio, have recently been put into operation and have been delivering steel to their new mill for the past month. It is of interest to note that these furnaces, employing an entirely new firing principle, have been giving results which have exceeded the expectations of all concerned. Each of the two furnaces were designed to heat 40 tons of blooms per hour, blooms being 18 ft. long x 10 in. x 10 in. It appears that each furnace will easily heat 50 tons when the new mill has been limbered up.

One of the features used on these furnaces is an independently fired soaking chamber, through which the blooms pass just before being discharged. This soaking chamber is separately controlled from the rest of the furnace although built as part of it, and is maintained at a constant uniform temperature. The two other sets of burners immediately behind the soaking chamber, fire above and beneath the blooms and it is these burners which determine the tonnage output of the furnace, the soaking chamber being used as the name implies, to soak the blooms thoroughly and equalize their temperature throughout.

* * *

The Youngstown Sheet & Tube Company has just recently placed a \$250,000 order for electrical equipment for a 44-in. electrically driven reversing blooming mill with the Westinghouse Electric & Mfg. Company.

This new equipment, which is to replace an existing steam engine drive that has been in operation for 14 years, will be installed in the Campbell works in about five months.

The mill will be driven by a 7000-hp. single unit d.c. reversing motor operated at 50-120 rpm. Power for the motor will be supplied by a flywheel motor generator set consisting of two 3000-kw., 700-volt generators operating at 360 rpm., one 5000-hp., 6600-volt, three-phase, 60-cycle a.c. motor, and a 140,000-lb. steel plate flywheel.

The equipment will be under the control of an operator located in the mill pulpit. A feature of the control is a foot operated master switch, which completely controls the reversing motor and allows the operator to take care of some of the auxiliary operations with his hands. It is expected that substantial savings in operating costs will be realized with this equipment over the present steam engine driven mill.

* * *

A project of unusual interest to industrial and public service companies has been announced by the Philip Carey Manufacturing Company, Cincinnati, Ohio, manufacturers of asbestos and magnesia high pressure steam pipe insulation, etc. This company is to construct at the Lockland, Ohio, works a boiler and power plant designed for 1800 lbs. steam pressure. This will be the highest steam pressure ever used in America, and the plant will be the largest high pressure steam plant in the world. W. E. S. Dyer, consulting engineer, Philadelphia, Pa., will design and have charge of the construction of the new work.

The high pressure steam generating equipment will be furnished by Combustion Engineering Corporation, of New York, and will operate at 1800 lbs. pressure. Integral economizers, water-cooled furnace walls, air preheaters, superheaters and pulverized fuel equipment will comprise these units.

The main generating units will consist of two 5000 hp. vertical triple expansion, direct connected engines, operating with 1400 lbs. pressure at the throttle, at a temperature of 800 deg. F. and exhausting against 60-lb. back pressure above the atmosphere. To each engine will be direct connected a 3-phase alternator.

All the equipment for this plant will be placed with American manufacturers, except the main engines which will be furnished by A. Borsig, of Berlin, Germany.

The operating cycle of this plant will make it one of the most efficient steam plants in the world.

COMING MEETINGS

Dec. 3-8—National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York City. Fred W. Payne, manager, Grand Central Palace, New York.

* * *

Dec. 3-8—Annual meeting, American Society of Mechanical Engineers, Engineering Society Building, New York City. Calvin Rice, secretary, 29 W. Thirty-ninth Street, New York.

* * *

Dec. 12-14—Fourth Annual Conference on Welding at Purdue University. Address Engineering Extension Department, Purdue University, Lafayette, Ind.

* * *

Jan. 14-18—Western Metal Congress, auspices American Society for Steel Treating at Los Angeles. W. H. Eisenman, secretary, 7016 Euclid Avenue, Cleveland, Ohio.

* * *

Jan. 14-18—Western States Metal and Machinery Exposition, auspices A.S.S.T. at Los Angeles. W. H. Eisenman, secretary, 7016 Euclid Avenue, Cleveland, Ohio.

New Home for Gears and Forgings

The recent consolidation of three prominent gear manufacturers and a large forge company that was announced sometime ago in these pages has exceeded all expectations in its successful operation.

Headquarters for the executive offices, sales, engineering, and planning departments have been established at the Cleveland division. In order to function with the utmost facility and efficiency, a complete modern administration building has been erected.



S. P. Kinney, metallurgist of the Bureau of Mines has resigned to become associated with H. A. Brasert & Company, consulting engineers of Chicago. Mr. Kinney was graduated as a bachelor of science in chemical engineering from the University of Utah in



1915. In 1916 he was occupied in the operation of mining properties in Utah and Nevada. In 1917 he entered the army. He was assigned to the Chemical Warfare Division and later commissioned second lieutenant. He worked in the laboratories of the War Department throughout the war and in 1919 became associated with the Bureau of Mines. He is best known as a leading participant in the investigations of the Bureau with regard to the iron blast furnace which have occupied

him for the past five years. These investigations have resulted in a quantitative estimation of many phenomena within the furnace and in a greatly improved understanding of practical conditions of iron manufacture. In 1926 Mr. Kinney received the J. E. Johnson, Jr., award for blast furnace research from the American Institute of Mining and Metallurgical Engineers.

* * *

James R. Stuart has recently resigned as superintendent of the open-hearth furnace department of the Colorado Fuel & Iron Company, Pueblo, Colo.

* * *

Mr. John A. Marr, for 10 years superintendent of the Nugent Steel Casting Company, Chicago, has been appointed works manager of the Chicago Steel Foundry Company.

* * *

Mr. R. J. McIntosh has been appointed manager steel piling department, in charge of engineering and sales, with offices at Bethlehem, Pa.

Walter F. Munnikhuysen has been appointed district engineer of The Koppers Construction Company, with offices at 823 Peoples Gas Building, Chicago, Ill.

* * *

Succeeding his father, the late Frederick S. Blackall, well known manufacturer and engineer, Frederick S. Blackall, Jr., was appointed general manager of The Taft-Peirce Manufacturing Company, Woonsocket, R. I., at a recent meeting of the board of directors. In addition to filling the position of general manager, Mr. Blackall, Jr., is also assistant secretary of the company, and a member of the board.

The company manufactures tools and special machinery on contract basis, and also manufactures and sells a line of small tools and machinery, including gages, production and inspection tools and thread milling machines.

* * *

John W. Hacker formerly superintendent of the coke plant of the Central Alloy Steel Corporation, Massillon, Ohio, has joined the Dyer Engineers, Inc., Cleveland. He is succeeded by John M. Komp.

* * *

Frank N. Speller, director of the department of metallurgy and research for the National Tube Company was elected chairman of the metallurgical advisory board, Carnegie Institute and U. S. Bureau of Mines, Pittsburgh, for a term of three years.

* * *

Ralph Kent has been named superintendent of the Rosedale coke works of the Cambria plant, Bethlehem Steel Company, succeeding E. R. Merrill, resigned. Mr. Kent has been associated with the Cambria plant for 24 years, first in the laboratory and later with the by-product unit of the coke works. Several years ago he was made superintendent of the Franklin unit. Jerry Wilbur, formerly general foreman at the Rosedale works, has been promoted to the position of superintendent of the Franklin works, filling the vacancy made by the promotion of Mr. Kent.

* * *

James W. Armour has been made vice president of the Riley Stoker Corporation. Mr. Armour still retains his title of engineering manager.



Fred C. T. Daniels, formerly division superintendent of open-hearth plant No. 1 steel and roll foundries, at the Bethlehem, Pa., plant of the Bethlehem Steel Corporation, has been made vice president in charge of operations of the Garrison and Midland plants of the Mackintosh-Hemphill Company, Pittsburgh. In accepting this position, Mr. Daniels returns to his first field of endeavor where he entered the employ of Mackintosh-Hemphill upon his graduation from Polytechnic Institute in 1904. In 1911 Mr. Daniels became connected with the Pittsburgh Iron & Steel Foundries Company, Midland, Pa., as assistant superintendent and metallurgist, being especially interested in the development and pioneering of alloy products for the rolling mill industry. From 1914 to 1923 he was employed by the Wheeling Mold & Foundry Company, being intimately connected with the sale, manufacture and use of iron, steel and alloy rolls. From 1923 to 1928 he was affiliated with the Bethlehem Steel Corporation.

* * *

Herbert C. Hale, special representative in Cleveland for the Elliott Company, Pittsburgh, has been transferred to Baltimore to handle all the company's government business exclusively. Mr. Hale is a graduate of the Case School of Applied Science and has been in Cleveland for the past 20 years.

* * *

Ralph Modjeski of the New York engineering firm of Modjeski, Masters & Chase, will act as consulting engineer in the construction of the Lorain-Central bridge to be built at Cleveland.

* * *

W. I. O'Connell, who has been a sales representative in Detroit for the Empire Steel Corporation, Mansfield, Ohio, resigned November 1 to become sales representative in Detroit for the Hines Steel Products Company.

* * *

Strickland Kneass, Jr., for three and a half years general manager and chief engineer of the Costello Engineering Company, Pittsburgh, has been made chief engineer for the A. M. Beyers Company, of Pittsburgh. Mr. Kneass had formerly been connected with

the Duquesne Works of the Carnegie Steel Company and later with the Youngstown Sheet & Tube Company, at Youngstown.

* * *

W. N. McCutcheon formerly with the Linde Air Products Company, New York City has been made general manager and chief engineer of the Costello Engineering Company, furnace designers and builders. Mr. McCutcheon had been connected with the Carbo-Hydrogen Company of America, in Pittsburgh, up to 1923 when he joined the Costello Company.

* * *

P. N. Guthrie, Jr., has been appointed vice president of the Reading Iron Company, which at the same time gave notice that the general sales offices of the company will be transferred from Reading, Pa., to 30 Church Street, New York City. Mr. Guthrie will have charge of sales and H. F. Mattern will continue as general sales manager. Mr. Guthrie was formerly connected with Park Brothers & Company, Black Diamond Steel Works, and later with the Philadelphia Company, of Pittsburgh.

Cleaning Up "Dirty" Steel

The results of certain phases of a general study of the physical chemistry of steel making, dealing specifically with the elimination of undesirable inclusions which are often responsible for the failure of steel are embodied in two bulletins just published by the Carnegie Institute of Technology, in co-operation with the United States Bureau of Mines, Department of Commerce, and the Mining and Metallurgical Advisory Board. Bulletin 36, by C. H. Herty, Jr., physical chemist of the Bureau of Mines, and G. R. Fitterer, research fellow, Carnegie Institute of Technology and junior metallurgist of the Bureau of Mines, deals with "Deoxidation with Silicon and the Formation of Ferrous-Silicate Inclusions in Steel." Bulletin 37, by Messrs. Herty and Fitterer, and J. F. Eckel, research fellow, Carnegie Institute of Technology, is a "Study of the Dickenson Method for the Determination of Non-metallic Inclusions in Steel."



THE STEEL PLANT ROLL TURNER AND DESIGNER

F. L. Thomas



In 1895, Mr. F. L. Thomas started to learn the trade of roll turner at the Joliet Works of The Illinois Steel Company. Here he was a roll turner, tool maker, template maker, and was in charge of the shop in 1902 when he resigned to accept a position of superintendent of roll turning at the Crucible Steel Company plant at Clairton, Pa. He resigned at the Crucible Steel Company, going to the Republic Iron & Steel Company at Moline, Ill., and later to the Tennessee Coal and Iron Company at Ensley, Ala. In July, 1904, he joined the organization of the Lackawanna Steel Company at Buffalo, N. Y., serving this company as roll turner, foreman of roll shop, and roll designer for all merchant mills for 16 years. He became associated with Donner Steel Company of Buffalo, N. Y., as superintendent of the roll shop in January, 1920.

G. H. Ackroyd

George H. Ackroyd, formerly superintendent of the Bethlehem Steel Corporation, Bethlehem, Pa., has been appointed superintendent of the steel foundry, iron roll foundry and machine shop at the Bethlehem plant.

Figuring Efficiency of Steel Mills

By Fred C. Smith

(Continued from last month)

Suppose that, instead of one size bar, two different sizes of the product are rolled in the same day. The following data are available:

Example II—

Collar diameter of finishing roll, $12\frac{3}{8}$ in.

$\frac{5}{8}$ -in. rounds, 914,015 lb. in 1008 min.

$\frac{3}{8}$ -in. rounds, 103,261 lb. in 423 min.

Total . . . 1,017,276 lb. in 1440 min.

Speed of finishing roll, 372.9 r.p.m.

Computing the theoretical productions as in example I, we find that under perfect conditions there should be produced:

1,224,495 ft. of $\frac{5}{8}$ -in. rounds

192,010 ft. of $\frac{3}{8}$ -in. rounds

To find the coefficient of efficiency of the mill, we add the theoretical production figures and divide the sum by the total production of both sizes:

$$1,017,276 \div 1,416,505 = 71.8 \text{ per cent}$$

Measured in terms of feet delivered, instead of weight, the theoretical production is:

1,173,917 ft. of $\frac{5}{8}$ -in. rounds

510,667 ft. of $\frac{3}{8}$ -in. rounds

Total 1,684,584 ft.

The length actually produced, found by dividing the production of each size in pounds by the weight of the respective product per foot, is

876,333 ft. of $\frac{5}{8}$ -in. rounds

274,630 ft. of $\frac{3}{8}$ -in. rounds

Total 1,150,963 ft.

And the coefficient of efficiency is:

$$E = 1,150,963 \div 1,684,684 = 68.3 \text{ per cent}$$

Here is a difference of 3.5 per cent between the coefficient of efficiency calculated on the basis of weight and that calculated on the basis of feet delivered. Obviously one or both are in error. Obviously, also, the error arises from the fact that the figures are averages of two separate coefficients. The coefficients are rates, and the arithmetic average of rates is not mathematically a true average. This may be seen from a simple illustration.

A man drives an automobile one mile at the rate of 20 miles an hour and one mile at the rate of 30 miles an hour. What is his average speed? It is not $20 + 30 \div 2$, or 25 miles an hour. Speed is expressed as distance per unit of time. The first mile, at 20 miles an hour, took 3 min. to traverse. The second mile took 2 min. The man traveled 2 miles in 5 min. The average speed is therefore

$$\frac{2}{5} \times 60 = 24 \text{ miles an hour}$$

This result may be more directly obtained by the use of a mathematical device, the harmonic mean. The harmonic mean is the reciprocal of the average of the reciprocals of the items. Applying this method to the problem of the average speed we have:

$$1 \div \frac{\frac{1}{20} + \frac{1}{30}}{2} = 1 \div \frac{\frac{50}{1200}}{5} = \frac{120}{5} = 24 \text{ mi. per hr.}$$

(To be continued)



THE STEEL PLANT BRICK MASON

Film Story of Brick-Making

Announcement is made by the U. S. Bureau of Mines, Department of Commerce, that a complete film story showing the various processes of manufacture of fire-clay refractories has been produced. The title of the film is "The Story of Fire-Clay Refractories," and shows the complete process of manufacture, from the mining of the clay to the sale of the finished product, at the plant of the Laclede-Christy Clay Products Company.

The Bureau of Mines will, without charge, furnish the film to be shown, the only conditions being that no fee is charged and that proper facilities (in a motion picture theater or elsewhere) be provided for exhibiting the film effectively. Parties to whom the film is loaned would be expected to assume all responsibility for its safe keeping and return to the bureau. Information pertaining to the securing of the film may be had by addressing U. S. Bureau of Mines, Washington.

—The Clay Worker.

Clay Products Exports Show Increase

Statistics furnished by the Department of Commerce indicate a substantial increase in foreign shipments of brick and other clay products in the seven months of the present year ended July 31. Following are the official figures for the seven-month period of this year, with comparative figures for the same months of last year:

	1927	1928
Fire-clay bricks	\$546,842	\$453,403
Other refractory bricks.....	700,993	686,955
Refractory shapes	410,551	694,378

In the seven months of the present year ended with July the imports of brick from foreign countries show a decided decrease from the figures for the same months of last year.

Pittsburgh Ceramic Society

The Pittsburgh Section of the American Ceramic Society held a meeting on Tuesday evening, November 13, at the Fellows Room of the Mellon Institute, that city. Spotts McDowell spoke on "Technological Developments on the Manufacture of Refractories," and many other features of interest marked the meeting.

Heat Transmission Through Walls

Building Research, of the Department of Scientific and Industrial Research of Great Britain, has recently issued as Technical Paper 6 an interesting pamphlet on "Thermal Conductivities of Walls, Concretes, and Plasters" by Ezer Griffiths. This paper is essentially a reprint of Special Report 7 of the same department, and has been issued because of numerous requests for the information contained in the original report. The general subject of heat transmission will be discussed in more expanded form in a special report now in preparation.

Those interested may procure copies of the pamphlet for 9d. net upon application to His Majesty's Stationery Office, London, England.

—Industrial and Engineering Chemistry.



Mr. Leo J. Loeper is superintendent of brick masons at the plant of the Carpenter Steel Company at Reading, Pa.

Steel Corporation Operates 179 Laboratories

At the recent meeting of the American Chemical Society at Swampscott, Mass., W. A. Forbes, assistant to the president of the United States Steel Corporation, explained the extent to which chemical and technological control is exercised in the steel industry, showing United States Steel Corporation and its subsidiary companies operate 179 laboratories devoted to chemical and physical testing with a complement of approximately 2,115 employees. This is the true index, he said, and emphasizes the importance and necessity of chemical science in the steel-making industry to render it still more efficient in quality of product, in minimizing waste, in utilizing by-products, and in enlarging the commercial diversification of all its products.

As to the future, he prophesied that chemists of a hundred years hence will probably regard as academic, or futile, our present day results.

The refinements in design and construction of open-hearth furnaces and maintaining, by chemical control, the quality of steel as larger capacity furnaces developed, together with strict chemical investigation and control of slags, fuels, gases, refractories, etc., have been exceedingly noteworthy during the last several years. The result is that steel producers have achieved uniform success in meeting the demands of steel consumers for products ever increasingly of higher quality, in order to withstand the many new and severe uses to which these steels are put today as compared with a few years ago.



THE STEEL PLANT BRICK MASON

Notes on the English and German Refractories Industry

By Stuart M. Phelps*

Although comparatively few plants were visited in these countries, those that were are of the more up-to-date or progressive type. There is little doubt that taken as a whole the foreign refractories industry is not as far advanced as in this country. One basic reason for this is the low cost of labor abroad. This condition naturally has not created an incentive for mechanical developments. Such a condition is not, by any means, universal as there are many plants that are comparable with those of the better class in this country. An example of such a plant is the silica brick works at Dusseldorf, Germany, which is modern and very thoroughly equipped mechanically.

In many instances their manufacturing methods differ by reason of the raw materials. Foreign quartzites are not as readily converted during firing, requiring 3 per cent of lime in place of the 2 per cent in this country. A variety of quartzites are blended to give the desired properties for brick and shapes. A universal practice is that of adding one-half of one per cent of an organic binder to the batch, which in part accounts for the excellent mechanical condition of their silica brick and shapes.

Flint clay does not occur in these countries, which necessitates the preparation of calcine as a substitute. At one plant a high grade kaolin brick was made in the following way: Kaolin was dug out of the pit by hand, made into a slip and put into large tanks so as to allow the fine silica sand to settle out. The slip was then filter-pressed and the cake made into dobies. These were placed in covered sheds to air dry and later were fired to 1,400 deg. C. Percentages of this calcine ranging from 60 to 80 per cent were used in the brick mixes. The final firing of the brick was to cone 16. Such a series of operation in this country would soon run up the cost and make an expensive product, but in Germany they sold for very little more than the price of our high grade clay brick.

Labor at this plant ranged from \$0.05 to \$0.20 per hour, the latter figure being that for molders. The cost of labor varies for different sections of the countries. In some districts women do most of the heavy work while in other parts, boys are employed extensively. The working conditions in many plants are of a very low order.

The firing of refractories in these countries is conducted on a very efficient basis. Coal costs about the same as in this country, and this figure in comparison with their other costs of manufacturing necessitates efficient firing.

The high efficiency obtained is the result of using continuous kilns which make use of the heat in the cooling ware and that present in the flue gases. Although this is the principle of the tunnel kilns used

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†The use of these materials was studied by the fellowship and reported in, "Organic Binders for Use in the Manufacture of Silica Brick," by H. Foster Robertson.

in this country, the operation of the continuous kiln is quite different.

These kilns are comparable in fuel economy with the more expensive tunnel kilns. Losses due to breakage and other causes appear to be considerably higher than that of tunnel kilns. Brick are fired to cone 10 to 12 with less than 800 lb. of coal and 1,100 lb. are used in firing to cone 15-16. They are not complicated in construction nor difficult to operate and appear to be quite satisfactory from the large number in use.

Tunnel kilns are not common either in England or Germany. The silica brick works at Dusseldorf has the most notable kiln, which incidentally, was the first to successfully fire silica brick.

This kiln is 500 ft. long and has a capacity of 70 to 80 tons of ware per day. The cars are about 7 ft. square and hold 10 tons of brick. A period of eight to 10 days is necessary to complete the passage through the kiln. Firing is accomplished with producer gas, using an equivalent of less than 600 lb. of coke breeze per 1,000 brick. The burning zone is 200 ft. long, accommodating 10 burners. Regeneration is used for both the gas and air.

An interesting furnace for calcining lump material was seen in Germany. It is used for the dead burning of magnesite and is the first of this type to be built. The lump material is fed into the charging door and falls upon the hearth, and is raked over its surface. After being heated for the necessary length of time, it is pulled forward and falls into a vertical cooling chamber. Air for combustion is drawn through the cooling material, preheating it, and is burned with the fuel in the combustion chamber. The flue gases give up their heat to the material in the charging chamber on their way to the stack. The kiln is fired with producer gas and is very efficient. An objection to its operation, however, is the necessity of hand labor in raking the material over the hearth. It would seem that a slow moving hearth on the principle of a stoker could be incorporated in its design. A practical and efficient calcining kiln would be very useful in this country for the preparation of flint clay, disasore, cyanide, magnesite, etc.

The price of clay brick in Germany ranges from \$20.00 to \$50.00, depending mainly on the quality as determined by the alumina content. Silica brick sell for about \$40.00, while in England the price is slightly higher. Clay brick in England sell for approximately the same as in Germany.

The use of specifications is not as extensive abroad as here, although they are gaining favor. Excellent technical work is being conducted in these countries, especially that of the more fundamental nature.

Basically, the industry is the same in all countries, but various conditions and customs are responsible for operations that appear to us to be quite odd or quaint. There is no doubt that it would be mutually worth while for manufacturers to exchange information and ideas, but on the other hand the industry in each country has been developed along lines that are peculiarly suited to their own conditions.

—Abstract from Technical Bulletin No. 25,
American Refractories Institute.



THE STEEL PLANT BRICK MASON

Some Properties of Refractories

Progress in development of refractories has been hindered by a lack of co-operation of consumers and producers. There has also been a great duplication of effort resulting from a lack of co-ordination of the work of different laboratories.

As a result of this situation the literature on refractories contains hundreds of pages of data, all good in itself but which cannot be beneficially interpreted and used because methods of testing have not been standardized.

An effort has been made by the writer to classify a number of representative refractory materials by collecting all data available on a few of their more important properties such as fusion temperature, resistance to load at high temperature, resistance to spalling, resistance to slag. The materials selected were silica brick, magnesite brick, chrome brick, disa-pore brick, and fire clay brick. Upon collecting data available and trying to figure the relative quality of these brick with respect to the properties outlined, on a percentage basis, the results obtained were so absurd that the problem was abandoned in despair. No two laboratories apparently follow the same procedure in making the simplest tests on refractories. It is difficult to find cases of agreement even on the fusion temperatures of refractories. The greatest need of the refractories industry today is a definition of terms, standardization of methods of testing and co-operation of all agencies in securing data which can be interpreted in the light of data already available.

The following tables taken from an article by F. H. Norton in the Journal of the American Ceramic Society, Vol. 8, No. 12, shows some of the properties

of common refractories. While these results are not in full agreement with those of some other investigators and while Norton's conclusion as to the properties controlling spalling have not met with full agreement, the tables do give a very good general comparison of the materials tested. A better understanding of the data given can be obtained from the article referred to (see tables).

TABLE II

Specimen No.	Material	Deg.	Melting point, deg.
15	Magnesite (Grecian) ..	2000	(pure 2800)
19	Lime	2000	(pure 2570)
13	Zirconia	2000	(pure 2550)
11	Zircon (white)	2000	
18	Spinel	2000	
20	Alumina	2000	(pure 2035)
10	Silicon carbide	2000	(decomposes at 2200)
12	Zircon (brown)	1935	
14	Mullite	1850	
5	Kaolin	1740	
1	Silica	1700	
6, 7, 8, 9	Fire clay (av.)	1670	
21	Insulating brick	1630	

It should be emphasized that a high melting point does not necessarily give high duty refractory, but a high melting point is a primary essential, before other properties can be considered.

In general, the material for a refractory structure should have as small a mean co-efficient of expansion as possible. In Table III the various specimens are listed in the order of excellence.

The brown zircon, kaolin and silicon carbide have the lowest co-efficients. The fire clay, mullite and zirconia are a little higher, while the spinel, alumina and

TABLE I

Specimen number	Type of brick	Melting point (reducing atmos.), deg.	Firing temperature, deg.	Mean coef. x 10 — 7 of expansion between 0° C. and shrinking temperature	Max. coef. x 10 — 7 of expansion between 300° C. and 700° C.	Max. irreversible contraction or expansion up to 1700° C., per cent	Inversion points, deg.	Changes in slope, deg.	Temp. at which shrinkage or expansion begins, deg.
1	Silica	1700	....	83	1000	1	260, 610	1400	1550
2	Kaolin	1740	1300	47	79	1	260, 600	....	1050
3	Kaolin	1740	1430	68	87	1	260, 600	....	1380
4	Kaolin	1740	1500	53	70	1	260, 600	....	1580
5	Kaolin	1740	1620	43	67	1	....	....	1610
6	Fire clay (Missouri)	1720	....	54	80	Large	600	....	1300
7	Fire clay (Pennsylvania) ..	1680	....	51	64	—5	600	1250	1250
8	Fire clay (Colorado)	1700	....	54	174	Large	260, 600	....	1220
9	Fire clay (Maryland)	1610	....	45	80	—3	....	....	1100
10	Silicon carbide	2000+	....	43	48	.	....	....	1700+
11	Zircon (white)	2000+	1650	64	92	Large	800	1400	1510
12	Zircon (brown)	1935	1590	42	48	2	600, 1400	....	1550
13	Zirconia	2000+	1675	59	87	1	800, 1150	....	1600
14	Mullite	1850	1785	53	82	.	780, 1350	....	1700+
15	Magnesite (pure)	2000+	1680	142	151	.	1430	1000	1700+
16	Magnesite (commercial) ..	....	....	147	210	2	....	500	1440
17	Chrome (commercial) .....	....	....	104	124	2	1000	1130	1540
18	Spinel	2000+	1690	76	110	1	....	1200	1600
19	Lime	2000+	1740	138	145	.	1500	700	1700+
20	Alumina	2000+	1650	77	82	1	1180		1580
21	Insulating	1630		74	480	Large	200, 570		1050



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silica form a still higher group. The chrome, lime and magnesite have values distinctly above the others. Structures made from the last three materials will require carefully designed expansion joints.

TABLE III

Specimen No.	Material	Mean co-efficient of expansion
12	Zircon (brown)	0.000042
5	Kaolin (hard)	.000043
10	Silicon carbide	.000043
6, 7, 8, 9	Fire clay (av.)	.000051
14	Mullite	.000053
13	Zirconia	.000059
11	Zircon (white)	.000064
21	Insulating brick	.000074
18	Spinel	.000076
20	Alumina	.000077
1	Silica	.000083
17	Chrome	.000114
19	Lime	.000138
15	Magnesite (Grecian)	.000142
16	Magnesite (commercial)	.000147

TABLE IV

Specimen No.	Material	Maximum co-efficient of expansion between 300° and 700°
12	Zircon (brown)	0.000048
10	Silicon carbide	.000048
5	Kaolin (hard)	.000067
14	Mullite	.000082
20	Alumina	.000082
13	Zirconia	.000087
11	Zircon (white)	.000092
6, 7, 8, 9	Fire clay (av.)	.000099
18	Spinel	.000110
17	Chrome	.000124
19	Lime	.000145
15	Magnesite (Grecian)	.000151
16	Magnesite (commercial)	.000210
21	Insulating brick	.000480
1	Silica	.0001000

TABLE V

Specimen No.	Material	Temperature at which shrinkage begins, deg.
10	Silicon carbide	1700+
14	Mullite	1700+
15	Magnesite (Grecian)	1700+
19	Lime	1700+
5	Kaolin (hard)	1610
18	Spinel	1600
13	Zirconia	1600
20	Alumina	1580
1	Silica	1550
12	Zircon (brown)	1550
17	Chrome	1540
11	Zircon (white)	1510
16	Magnesite (commercial)	1440
6, 7, 8, 9	Fire clay (av.)	1220
21	Insulating brick	1050

As previously stated the ability of a material to resist spalling depends, other things being equal, on the maximum co-efficient of expansion between 300 and 700 deg. In most cases this will be the maximum for the complete temperature range. The different

materials are listed in Table IV to bring out their spalling resistance.

The materials most resistant to spalling are zircon, silicon carbide and kaolin. Mullite, alumina, zirconia, fire clay and spinel are somewhat less resistant, and chrome, lime and magnesite will spall rather easily.

—By Professor J. B. Shaw, Dept. Ceramic Eng., Pennsylvania State College

Present Status of Structural Steel Welding

(Continued from page 1586)

3—Competitive costs are frequently securable on existing bridges and other structures which require reinforcement to meet added loadings. The saving here is largely due to the avoidance of the expensive hand-drilling of holes in the field.

4—Competitive costs may not be securable on the taller beam-and-column buildings, whose details are so important as to require shop preparation, until such time as there is enough business of this character to occupy a shop continuously.

5—There is a class of tall beam-and-column buildings which, from a broader economic standpoint, can be welded with advantage, regardless of present costs for such work. This class embraces additions to buildings already occupied, where the elimination of noise during construction has real monetary value. Hotel owners are becoming alive to this feature and it is also a factor in some other commercial buildings as well as in the case of hospitals and colleges. The saving of space during alterations, and the smaller amount of demolition made possible by welding, also make this process economical as applied to the detailed connections of a new to an existing structure.

In conclusion, it may be convenient to sum up the answers here attempted.

1—Standard grades of structural steel, such as those covered by A.S.T.M. Specifications A-7 or A-9, can be satisfactorily welded. Many special grades also seem well suited to welding.

2—The welding operation does not adversely affect standard structural grades of base metal. It gives a highly localized normalizing treatment, with exactly the same results as accompany the well-known process of heat treatment.

3—Methods of making welds by different processes have been standardized to a considerable degree.

4—Unit values for the strength of welded joints can be readily determined. Safe values for the most usual forms of joint, under static load, are already known.

5—The welded resembles the riveted joint in that its absolute soundness is determinable only by destructive test. The practical soundness of a welded joint is readily determinable, without destructive test, by the taking of certain precautions, of which the most important are the periodical qualification of each welder by specific test and the selection of suitable welding wire.

6—At the present time the economic advantage of welding varies with different classes of work.

SAFETY FIRST IN THE STEEL PLANT

National Safety Council

From a mere handful of pioneers, the National Safety Council has grown into an organization of world-wide leadership. It is supported by 4,650 members, representing 153 different kinds of industries, government departments, educational institutions, libraries, chambers of commerce, community safety councils, insurance companies, automobile clubs, miscellaneous national, state and local professional, trade and business organizations and public spirited individuals.

At the seventeenth annual safety congress in October at the sessions of the metals section papers were read covering subjects of prime importance to the steel industry in its work of accident prevention including "Safety from the Viewpoint of Management," by R. M. Roosevelt, vice president, Eagle Pitcher Lead Company, New York City; "Safety from the Viewpoint of Supervision," by Dominic Samuels, foreman, Youngstown Sheet & Tube Company, Youngstown, Ohio; "Correction of Unsafe Practices in Foundries," by Nelson H. Kyser, safety engineer, Studebaker Corporation of America, South Bend, Ind.; "Developing a Safe Human Factor in Our Industries," by L. A. Hartley, director, Educational Department, National Founders' Association, Chicago; "The Placement of Men, or What the Surgeon Can Do," by A. W. Colcord, M.D., plant surgeon, Clairton Works, Carnegie Steel Company, Clairton, Pa., and "Review of Accidents and Progress in the Steel Industry," by Dr. L. W. Chaney, Bureau of Labor Statistics, U. S. Department of Labor, Washington, D. C.

Records in the Steel Mills

The Reading Iron Company Works, at Pottstown, with 125 employes had 2 lost-time accidents in 1927. One of these was caused by an employe falling from a truck only 12 in. above ground and injuring his thumb. Up to June 4 this plant had no lost-time accidents in 1928. The superintendent and foremen are responsible for safety.

The American Steel and Wire Company, at its Farrell plant can show an accident decrease of 74.48 per cent in the last 8 years. In 1920 the accident record at the Farrell works was 2.39 per hundred men. In 1927 the record was .61.

—From Labor and Industry.

Progress in Safety

Reduction of waste, through preventive measures in that greatest of all national resources—human life—has gone forward steadily, yet much remains to be done in this direction. As our population grows, and as our means of locomotion increase in variety and speed, and as the number of persons engaged in hazardous occupations and pursuits increases, we are confronted in increasing magnitude with the problem of safety and protection to human life.

Through educational and legislative measures, through extension of compensation insurance into areas not now reached by it, and by quickened public interest in the wisdom and value of such effort will we accomplish the reduction of our annual fatalities. It has been well demonstrated that a large percentage of these are avoidable, and because of that fact we should assume a greater personal and national responsibility toward their prevention.

Through its Bureau of Standards the department is co-operating continually with the various bodies concerned in the development, promulgation, publication, and revision of safety codes.

Among the latter are the national safety code for the protection of heads and eyes of industrial workers, the American logging and sawmill safety code, the national electrical safety code,

safety rules for installation and maintenance of electrical supply stations, of electric utilization equipment, and of electrical supply and communication lines. To this list must be added because of the newness of the hazard safety rules for radio installation.

Other codes need to be developed for fields still uncovered in this respect, and current efforts to complete codes for fields partially covered need to be encouraged and supported. A responsibility which can not be evaded rests upon industrial managers to make safety a major interest and a continuing care.

Investigations designed to bring about safer and more healthful working conditions in our mineral industries have been extended. Among the more important of these mine-safety studies are those concerned with the prevention of mine explosions—the reduction of heavy loss of life from falls of mine roof and coal, the elimination of hazards from the use of unsafe types of explosives and mechanical equipment, improvement of ventilation in mines, and the instruction of miners in first-aid and mine-rescue methods.

—From report of the Secretary of Commerce.



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The Blast Furnace *and* Steel Plant

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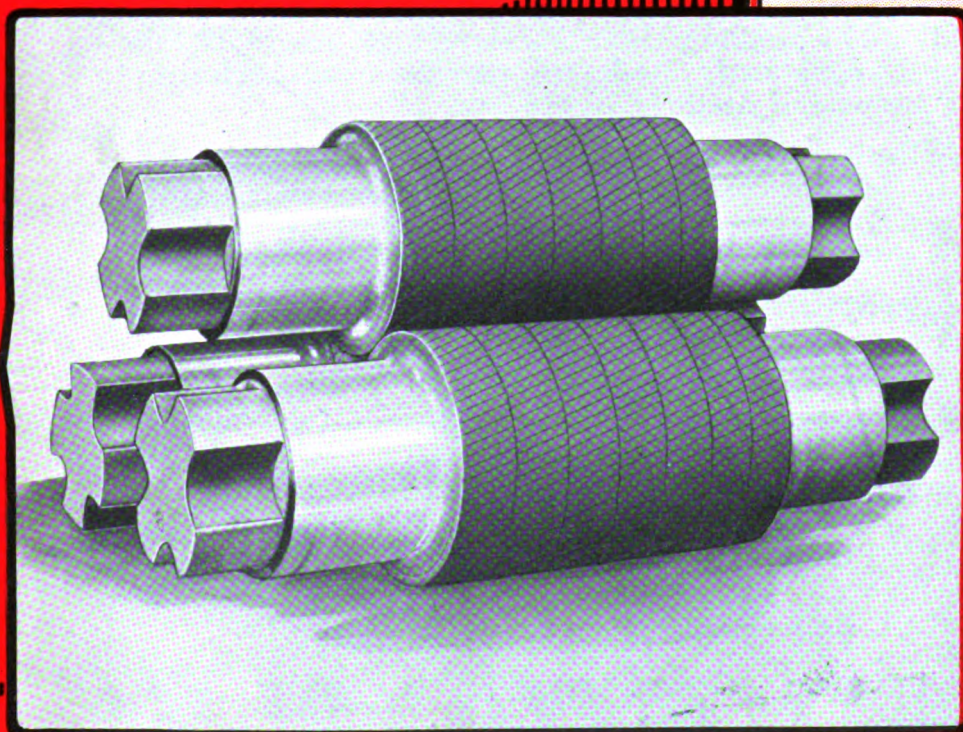
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